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VOL. CXLII.—No. 3695] LONDON: FRIDAY EVENING, NOVEMBER 5, 1926 [PRICE ONE SHILLING BY INLAND POST 1s. 3d.

PUBLIC NOTICES

The Director - General, India Store Department, Branch No. 15, Belvedere-road, Lambeth, S.E. 1, invites TENDERS for :—

1. 32,000 R. ft. W.I. or M.S. TUBING, Gas Quality, Butt Welded, Galvanised.
2. ROAD BRIDGES—Five 80ft. Clear Pony Truss Spans (approx. 213 tons).
3. EIGHT ELECTRIC CRANES, OVERHEAD TRAVELLING, 10 and 25 Tons.

Tenders due on the 19th November, 1926, for No. 1, and on the 23rd November, 1926, for Nos. 2 and 3.
Specifications and forms of Tender obtainable from the above at a fee of 5s. per set, which will not be returned. 3906

Civil Engineer Required QUIRED by the GOVERNMENT of the GOLD COAST for the Cape Coast Water Supply, for a tour of 12 to 18 months' service, with possible extension. Salary £480, rising to £920 a year. Free quarters and passages and liberal leave on full salary. Outfit allowance of £60 on first appointment. Candidates, aged 25 to 35, should be fully trained Civil Engineers, preferably A.M.I.C.E., who have had experience in Waterworks Construction and Pipe Laying.—Apply at once by letter, stating age, qualifications and particulars of experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/14979. 3918

Civil Engineer Required QUIRED by the GOVERNMENT of the GOLD COAST for two tours of 12 to 18 months' service, with possible extension. Salary £480, rising to £920 a year. Free quarters, passages and liberal leave on full salary. Outfit allowance of £60 on first appointment. Candidates, aged 23 to 35, should have had good training under Corporate Member of Institution of Civil Engineers, and have passed parts A and B of examination qualifying for Associate Membership of Institution or hold an Exempting Degree in Engineering. Must be quick and accurate with Level or Theodolite.—Apply at once by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, London, S.W. 1, quoting M/14963. 3921

Draughtsman Required for NIGERIAN RAILWAY CONSTRUCTION for a tour of 12-18 months' service, with possible extension. Salary £480 for the first three years of service, then rising by annual increments to £720 a year. Commuted bush and travelling allowance of £9 a month whilst on duty in the Colony. Free passages and camp equipment provided. Outfit allowance of £60 on first appointment. Liberal leave on full salary. Candidates, age 25-40, should have had good training in general CIVIL Engineering Drawing-office Work.—Apply at once by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/14950. 3920

Draughtsman Required for the PUBLIC WORKS DEPARTMENT of KENYA COLONY for a tour of 30 months' service. Salary £480, rising to £660 a year by annual increments of £30, and thence rising to £720 a year by annual increments of £30. Outfit allowance of £30 on first appointment. Free quarters and passages, and liberal leave on full salary. Candidates, aged 25 to 35, must be fully trained and experienced in the office of a fully qualified Civil Engineer, should be experienced in the design of buildings and be competent to prepare working drawings rapidly and efficiently of large buildings from sketches; should be able personally to undertake engineering survey work.—Apply at once by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W. 1, quoting M/14871. 3919

One Assistant Dredging MASTER required for service under the Government of Bombay. Experience on the working of Suction Cutter Dredgers desirable, but not essential.
Two years' agreement. Free second class passage to India and return passage on satisfactory termination of services. Pay on a scale of Rs. 600, rising by annual increments of Rs. 50 to Rs. 800 per calendar month. Medical examination. Forms of application and further particulars may be obtained from the SECRETARY to the HIGH COMMISSIONER FOR INDIA, General Department, 42, Grosvenor Gardens, London, S.W. 1. Last date for receipt of applications 24th November, 1926. 3894

Crystal Palace School of Practical Engineering.
Founded 1872.
MECHANICAL AND CIVIL ENGINEERING DIVISIONS.
PRESIDENT: J. W. WILSON, M.I.C.E., M.I.M.E.
PRINCIPAL: MAURICE WILSON, M.I.C.E.
Assisted by Staff of Lecturers and Instructors.
Thorough, up-to-date Practical and Theoretical Instruction. Course completed in 2 years.
Students admitted at beginning of any term. 3685

Institution of Structural Engineers.
MODIFIED EXAMINATION FOR ASSOCIATE-MEMBERSHIP.
This Examination is held quarterly for candidates of and over 25 years of age, having 10 years' practical experience, including time served in articles. It consists of a problem in design with a little additional work, which is carried out by the candidate at his own home. The NEXT EXAMINATION will be held on NOVEMBER 20th, and entries should reach me before November 15th. Syllabus and full particulars from the undersigned.
MAURICE G. KIDDY, F.I.S.A.,
Secretary.
10, Upper Belgrave-street, S.W. 1. 3779

Institution of Structural Engineers.
EXAMINATIONS FOR GRADUATESHIP AND ASSOCIATE-MEMBERSHIP.
The next EXAMINATIONS will be held on DECEMBER 1st (Graduateship) and DECEMBER 2nd-3rd (Associate-Membership); closing date for entry November 22nd.
Centres have been arranged in London, Manchester, Norwich, Johannesburg, Madras, Bombay, and Wellington, New Zealand. Further centres may be arranged according to the candidates forthcoming.
Syllabus and full particulars from the undersigned.
MAURICE G. KIDDY, F.I.S.A.,
Secretary.
10, Upper Belgrave-street, S.W. 1. 3780

The Engineer

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Boiler House Extensions at St. Pancras Electricity Works. THE ENGINEER, 5 - 11 - 26.

PUBLIC NOTICES

Borough of Hastings Water-Works.
TO MANUFACTURERS OF CENTRIFUGAL DEEP WELL PUMPS OR ELECTRICAL CONTRACTORS.
The Corporation of Hastings invite TENDERS for the complete EQUIPMENT of a PUMPING PLANT in each of two separate Pumping Stations to be erected over two bored wells.
The works included in the contract consist of turbine or centrifugal deep well pumps driven by electric motors, together with all electrical equipment and connections inside each building, in accordance with the drawings, general conditions and specification prepared by the Engineer, Mr. G. Midgley Taylor, of Messrs. John Taylor and Sons, Caxton House, Westminster, S.W. 1.
The general conditions, specification and form of Tender may be obtained by the manufacturer or contractor at the office of the Engineer upon payment of £5 (cheque only), which will be returned upon receipt of a bona fide Tender.
Tenders, in sealed envelopes, endorsed "Tender for Pumping Plant," must be delivered at my office at the Town Hall, Hastings, on or before Noon on Tuesday, the 30th day of November, 1926.
The Corporation do not bind themselves to accept the lowest or any Tender.
(Signed) D. W. JACKSON,
Town Clerk.
Town Hall, Hastings. 3805

Brighton Intercepting and Outfall Sewers Board.
RECONSTRUCTION OF SEWER OUTFALL AND CONSTRUCTION OF SEA WALL.
TENDERS are INVITED by the above Board for the RECONSTRUCTION of the existing OUTFALL at Portobello, together with SEA WALL and other incidental Works.
The works include the laying of two lines of 60in. diameter Cast Iron Pipes, with an approximate length of 640 yards, and a Sea Wall about 150 yards in length.
Plans may be seen and general conditions, specification, quantities and form of Tender may be obtained at the office of the Engineer to the Board, Mr. David Edwards, M. Inst. C.E., Town Hall, Brighton.
A deposit of Ten Guineas will be required, which will be returned on the receipt of a bona fide Tender.
Sealed Tenders, endorsed "Contract for Sewer Outfall and Sea Wall," to be delivered at the office of the undersigned on or before November 30th, 1926.
The Board does not bind itself to accept the lowest or any Tender.
(Signed) JAS. H. ROTHWELL,
Clerk to the Board.
Town Hall, Brighton. 3840

PUBLIC NOTICES

Barking Town Urban District Council.
TENDERS FOR ROAD ROLLER.
TENDERS are INVITED for the SUPPLY and DELIVERY of a ROAD ROLLER, weighing 8 tons when fully loaded.
Full particulars and form of Tender can be obtained upon application to Mr. E. A. Lay, Assoc. M. Inst. C.E., Engineer and Surveyor to the Council, Public Offices, East-street, Barking.
Tenders should be forwarded in the special envelope provided for the purpose, so as to reach the undersigned not later than 5 p.m. on Tuesday, the 23rd of November, 1926.
The Council do not bind themselves to accept the lowest or any Tender.
By Order,
H. HARGREAVES,
Clerk to the Council.
Public Offices, Barking,
2nd November, 1926. 3903

County Borough of Brighton.
The Corporation invite TENDERS from British firms only for the SUPPLY, DELIVERY, and ERECTION at their Power Station, Southwick, near Brighton, of :—
ONE 15,625 K.W. (M.C.R.) TURBO ALTERNATOR with CONDENSING PLANT and AUXILIARIES.
Specifications and drawings may be obtained on application to Mr. John Christie, Electricity Department, North-road, Brighton, on payment to him of the sum of £3 3s. This amount will be returnable only if bona fide Tenders are submitted and not previously withdrawn.
Sealed Tenders, marked "Tender for Turbo Alternator," must be delivered to the undersigned not later than Twelve Noon on Thursday, the 25th November, 1926, at the Town Hall, Brighton.
The Corporation do not bind themselves to accept the lowest or any Tender.
JAS. H. ROTHWELL,
Town Clerk.
Town Hall, Brighton,
28th October, 1926. 3881

The Madras and Southern Mahratta Railway Company, Limited, 25, Buckingham Palace-road, Westminster, S.W. 1, invite TENDERS for :—
GIRDER BRIDGES (Spans from 10ft. to 60ft.) and FLANGE PLATES. (A total approximate tonnage of 198.6 tons.)
Tenders are due in on Tuesday, 30th November, 1926, by 10.30 a.m. Tender forms obtainable at above address; fee One Guinea, which is not returnable.
The Directors do not bind themselves to accept the lowest or any Tender. 3869

PUBLIC NOTICES

County Borough of Southampton.
DOUBLE SOCKET SLUICE VALVES.
The Corporation invite TENDERS for the SUPPLY of HEAVY CAST IRON DOUBLE SOCKET SLUICE VALVES, 2in. to 12in. diameter.
Particulars and form of Tender can be obtained from the Waterworks Engineer's Office, 21, Shirley road, Southampton.
Sealed Tenders, endorsed "2in. to 12in. Sluice Valves," must be delivered at the Town Clerk's office not later than 10 a.m. on 11th November, 1926.
The Council do not bind themselves to accept the lowest or any Tender.
R. R. LINTHORNE,
Town Clerk.
22nd October, 1926. 3831

County Borough of Southampton.
C.I. PIPES AND SPECIAL CASTINGS.
The Southampton Corporation invite TENDERS for the SUPPLY of the following C.I. SPIGOT and SOCKET PIPES :—

1000	.. ..	3in. diameter.
100	.. ..	8in. "
80	.. ..	10in. "
12	.. ..	18in. "
12	.. ..	24in. "
20	.. ..	30in. "

Also about 12 TONS of SPIGOT and SOCKET SPECIAL CASTINGS.
Specification, schedule and form of Tender may be obtained from the Waterworks Engineer's Office, 21, Shirley-road, Southampton.
Sealed Tenders, endorsed "Cast Iron Pipes," must be delivered at the Town Clerk's office not later than 10 a.m. on the 11th November, 1926.
The Council do not bind themselves to accept the lowest or any Tender.
R. R. LINTHORNE,
Town Clerk.
22nd October, 1926. 3832

South Indian Railway Company, Limited.
The Directors are prepared to receive TENDERS for the SUPPLY of—
STEELWORK for BRIDGES.
Specifications and forms of Tender will be available at the Company's offices, 21, Petty France, Westminster, S.W. 1.
Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for Steelwork for Bridges," must be left with the undersigned not later than Twelve Noon on Friday, the 3rd December, 1926.
The Directors do not bind themselves to accept the lowest or any Tender.
A charge, which will not be returned, will be made of 10s. for each copy of the specification.
Copies of the drawings may be obtained at the offices of Messrs. Robert White and Partners, Consulting Engineers to the Company, 3, Victoria-street, S.W. 1.
A. MUIRHEAD,
Managing Director.
91, Petty France, S.W. 1,
2nd November, 1926. 3913

Required for Service on the Great Indian Peninsula Railway (Indian State Railways).
TOOL-ROOM CHARGEMAN. Candidates must be capable of supervising the manufacture of jigs, gauges and dies, and the manufacture and grinding of all classes of tools used in a large machine shop (such as milling cutters, taps, reamers, chasers, &c.). Also have had considerable experience on the heat treatment of various classes of special steels employed in tool manufacture. Experience and training in a large tool-room essential. Railway shop experience not necessary. Age not over 35 years.
SALARY.—Rs. 580, rising by annual increments to Rs. 625 per calendar month.
TERMS.—The terms of the appointment will include a five years' agreement in the first instance, with a free second-class passage to India and return passage on satisfactory termination of service, and admission to the benefits of a Provident Fund. Selected candidate will only be appointed subject to satisfactory references and to a strict medical examination. Applicants must give their age, whether married or single, with full particulars in chronological order of their training and subsequent experience, stating the names of firms by whom they have been employed and the class of work engaged upon, with dates in each case. If employed abroad before, details should be given, with copy of leaving certificate.
Letters of application, which must be marked outside with the designation of the post, and be accompanied by COPIES ONLY of testimonials, should be addressed to the undersigned not later than 27th November, 1926.
RENDEL, PALMER and TRITTON,
12-14, Dartmouth-street, London, S.W. 1. 3891

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PUBLIC NOTICES

Great Southern Railways Company.

CONTRACTS, 1926.

The Directors of the Great Southern Railways Company are prepared to receive TENDERS for the SUPPLY of the undermentioned STORES for six months, commencing 1st January, 1927, and alternatively for twelve months, commencing the same date.

	No. of Form.
Acid, Sulphuric	3D
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Axles, Straight, for Carriages and Wagons	103
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Blooms, Steel, for Locos.	100
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Brooms and Brushes	13
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Brass Sheet Wire, &c.	113
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Cement, Portland	34
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Forms of Tenders can be obtained on payment of 6d. each from the Stores Superintendent, General Stores Department, G.S. Rlys., Inchicore, Dublin. Applications for forms by post must be accompanied by postal order. Stamps cannot be accepted. All inquiries for information should be directed to the Stores Superintendent.

Patterns may be inspected at the General Stores Department, Inchicore, on and after the 16th instant, between the hours of 10 a.m. and 4 p.m. (except on Saturdays).

Tenders must be enclosed in the special envelope supplied for the purpose with each schedule, and must be posted so as to be with the undersigned before 10 a.m. on Thursday, 9th December, 1926.

The Directors will not consider any Tender unless it is furnished on the Company's form, and do not bind themselves to accept the lowest or any Tender.

The decision of the Directors will be communicated not later than Friday, the 14th January, 1927, to those firms only whose Tenders are accepted.

By Order,
C. E. RILEY,
Secretary.

Kingsbridge Terminus, Dublin,
November, 1926. 3886

City and County of Kingston-upon-Hull.

APPOINTMENT OF CITY ENGINEER.

The Corporation of Kingston-upon-Hull invite APPLICATIONS for the POSITION of CITY ENGINEER of the City at a salary of £1250 per annum (no bonus).

The person appointed will be required to devote his whole time to the duties of the office and will not be allowed to engage in private practice, and all emoluments out of public monies which may be payable to or received by him will have to be paid to the Corporation. He will be required to contribute to the Corporation Superannuation Fund and to pass a medical examination.

Particulars of duties and forms on which applications should be made may be obtained from the Town Clerk.

Applications, endorsed "City Engineer," addressed to the Town Clerk, Guildhall, Hull, must be delivered at the Town Clerk's Office, Hull, not later than 30th November, 1926.

H. A. LEAROYD,
Town Clerk.

Guildhall, Hull,
28th October, 1926. 3885

Municipality of George Town, Penang, Straits Settlements.

ASSISTANT ENGINEER.
ADVERTISEMENT.

The Municipal Commissioners of George Town, Penang, REQUIRE an ASSISTANT ENGINEER, aged about 30-32, preferably unmarried, on a three years' agreement, with possible extension.

Applicants must have had a good technical education and regular training as pupil and assistant, preferably in a Municipal or County Engineer's office, and must possess experience in Municipal and General Engineering, including Roads, Buildings, Bridges, Sewerage and Conservancy Work, and the control of workmen.

Candidates must be corporate members of the Institution of Civil Engineers, and preference will be given to those who have passed the Testamur Examination of the Institution of Municipal and County Engineers.

The work of this appointment includes the direction of European engineers and staff and demands organising ability and energy.

Salary, 8400 dollars for the first year, 8700 dollars for the second year, and 9000 dollars for the third year of the agreement, rising thereafter by annual increments of 300 dollars a year to 10,200 dollars per annum.

Salary will be paid monthly in dollars, the currency of the Colony, the value of the dollar being 2s. 4d. sterling. In addition, there is at present a temporary allowance of twenty per cent. on the salary for married men and ten per cent. for unmarried men, but these allowances are subject to revision or cancellation at any time. The pay of the appointment at the above rate for the first year, including the temporary allowance, would be £1176 for a married man and £1078 for a single man. An allowance for the maintenance of a motor car when on duty will be granted. Free passage will be provided, with half-pay during the voyage out. The selected candidate must pass an approved medical examination.

Applications, stating whether married or single, age, birthplace, and giving details of education, training and experience generally, with particular reference to the qualifications mentioned above, and accompanied by copies (not originals) of testimonials, to be lodged with Messrs. PEIRCE and WILLIAMS, MM. Inst. C.E., 64, Victoria-street, London, S.W. 1, Agents for the Commissioners, not later than 17th November, 1926.

Further particulars, if desired, can be obtained from the Agents. 3883

PUBLIC NOTICES

Municipality of George Town, Penang, Straits Settlements.

RESIDENT ENGINEER ASSISTANT.
ADVERTISEMENT.

The Municipal Commissioners of George Town, Penang, REQUIRE a RESIDENT ENGINEER ASSISTANT upon their new Water Supply Works, aged 25-30, preferably unmarried, on a two years' agreement, with possible extension for a further period of one year.

He will be required to assist the Water Engineer in the design and construction of Water Supply Works from upland sources, comprising River Intakes, Conduits, Tunnels, Pipe Lines, Service Reservoirs and Pumping Installations.

Applicants must have had a good technical education and a regular training as pupil and assistant with a Borough or County Engineer or a Civil Engineer in private practice, preferably in an office handling works of water supply, and must possess experience in surveying, levelling and estimating for and in the construction of general civil engineering works, and in particular of waterworks. Experience in the carrying out of work by direct labour is desirable.

Applicants should be Corporate Members of the Institution of Civil Engineers.

Salary 8400 dollars per annum for the two years of the agreement. The salary will be paid monthly, in dollars, the currency of the Colony, the value of the dollar being 2s. 4d. sterling. The pay of the appointment at this rate of exchange will be £980 per annum.

Such local transport as may from time to time be granted by the Commissioners will be paid.

Free passage will be provided, with half pay during the voyage out and home, and the selected candidate must pass an approved medical examination.

Applications, stating whether married or single, age, birthplace, giving details of education, training and experience generally, with particular reference to the qualifications mentioned above, and accompanied by copies (not originals) of testimonials, to be lodged with Messrs. PEIRCE and WILLIAMS, MM. Inst. C.E., 64, Victoria-street, Westminster, London, S.W. 1, Agents for the Commissioners, not later than 10th November, 1926. Further particulars, if desired, can be obtained from the above-named firm. 3933

Epsom Union.

NON-RESIDENT ASSISTANT ENGINEER.

The Guardians of the Epsom Union REQUIRE the SERVICES of an ASSISTANT ENGINEER at the Guardians' Institute, Dorking-road, Epsom. Salary £2 5s. per week, rising 5s. per week annually, subject to approved service, to a maximum of £3 per week. Applications, on forms to be obtained from the undersigned, must be received by me not later than first post on Wednesday, the 17th of November, 1926.

The appointment will be subject to the provisions of the Poor Law Officers Superannuation Act, 1896, and the National Insurance Acts. The person approved must be a qualified plumber with domestic engineering experience and will be required to assist the engineer and make himself generally useful. Previous experience in an institution will be a recommendation.

By Order,
ALICK G. EBBUTT,
Clerk.

"Gynsdale," Waterloo-road, Epsom.
4th November, 1926. 3922

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

WANTED, TECHNICAL ASSISTANT for Works Manager's Office in important Steel Structural Works. Must be young and keen with previous experiences.—Address, stating age, qualifications, experience and salary expected, 3833, The Engineer Office. 3833 A

WANTED, Young ENGINEER, with Experience of the Preparation of Tenders for Diesel Engine Plant, both land and marine.—Address in the first instance, stating full particulars and salary required, 3889, The Engineer Office. 3889 A

ASSISTANT WORKS MANAGER WANTED, Age 30 to 40, for Scottish firm specialising in Mechanical Handling Plants; modern workshop experience essential; salary, £250 to £300, according to experience.—Address, Billy, P2404, The Engineer Office. P2404 A

WORKS ENGINEER WANTED, with Experience of Non-ferrous Rolling Mill, Foundry, &c. Knowledge of use of Machine Tools essential.—Address, stating age, experience, salary required, &c., 3901, The Engineer Office. 3901 A

WORKS ENGINEER REQUIRED, with All-round experience of Mill Work, Boilers, Hydraulic Plant, Electric Power, A.C. and D.C., competent of steam and power saving. Candidate to be between 35 and 40 years of age. Copies of testimonials to be given, also details of technical college certificates. State salary.—Address, 3902, The Engineer Office. 3902 A

WORKS ENGINEER, with Practical Knowledge of Electric Motors and Cables for Power and Light, Boilers and Steam Heating Installation, Air Compressors and Service, Countershafts and Power Transmission.—Address, 3822, The Engineer Office. 3822 A

YOUNG MAN (24-28 Years), Good Personality, with initiative and ambition and some mechanical knowledge, ability to handle men and TAKE RESPONSIBILITY in a MANUFACTURING DEPARTMENT.—Address, P2448, The Engineer Office. P2448A

DESIGNER REQD., with Good Exp. Dairy Machinery esn. £400/600 p.a., according to qualifications.—Apply, LAURIE'S, Employment Specialists, 28, Basinghall-st., E.C. 2. No preliminary fee. 3917 A

DRAUGHTSMAN REQUIRED AT ONCE, London, previous experience Refrigeration Work necessary. State age, experience and salary required.—Address, 3912, The Engineer Office. 3912 A

DRAUGHTSMAN (SENIOR), Used to Fan Design and Application. State age, experience, when at liberty, and salary required.—Address, 3887, The Engineer Office. 3887 A

DRAUGHTSMAN WANTED, Thoroughly Experienced in Detailing Mechanical and Structural Work for Conveyor Plants, &c. State age, experience and salary required.—Address, 3914, The Engineer Office. 3914 A

FIRST-CLASS DESIGNING DRAUGHTSMAN for Chassis Components and Lay-out of Heavy Passenger-carrying Vehicles.—Application by letter, stating age, experience, and salary required, to TILLING-STEVENS MOTORS, Limited, Maidstone. 3886 A

FIRST-CLASS DESIGNER (Mechanical) REQUIRED for Midlands. Training in leading technical college essential and general Drawing-office experience in good works. State age, full particulars and salary required.—Address, 3909, The Engineer Office. 3909 A

GOOD SENIOR DRAUGHTSMEN WANTED for Water Turbine Details; previous W.E. experience not essential.—Write, stating age, training, experience, salary expected and date free, to CHIEF DRAUGHTSMAN, English Electric Co., Ltd., Rugby. 3911 A

MECHANICAL DRAUGHTSMAN REQUIRED Temporarily. One essentially accustomed to detail work on Engines or Compressors.—Address, stating age, experience, and salary required, P2412, The Engineer Office. P2412 A

SITUATIONS OPEN (continued)

WANTED, FOREMAN MOULDER, Used to General Engineering Work up to 3 tons, also Repetition Work, including Double Flanged Pipes, Socket and Spigot Pipes.—Address, stating age, salary, when at liberty, 3845, The Engineer Office. 3845 A

FOREMAN WANTED for Engineers, Mechanical; 30 hands, London.—Write in confidence, stating age, experience, wages. Good timekeeper essential. —Box 290, Sells' Advertising Offices, Fleet-street, E.C. 4. 3915 A

PATTERNMAKERS.—Permanency for Capable Men. District rate.—Apply, P. J. SMITH, 24, Wynratt-street, Goswell-road, E.C. 1. 3884 A

SITUATIONS WANTED

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For continuation of Small Advertisements see page 3.

A Seven-Day Journal

L.M.S. Railway Adminstration.

THE intimation made on Thursday of last week that Mr. Burgess was definitely retiring, after fifty-three years service, on March 31st next, from the position of general manager to the London, Midland and Scottish Railway, was quite in accordance with anticipations. The railway world was not, however, prepared for so drastic an innovation—for British railways—as the appointment of four vice-presidents to assist Sir Josiah Stamp, who will continue to be the President, and for the office of general manager to be abolished. The four vice-presidents are Mr. S. H. Hunt, Mr. J. Quirey, Mr. J. H. Fellows, and Mr. R. W. Reid. Mr. Hunt is an old London and North-Western officer, and is now the London, Midland and Scottish chief goods manager. His new duties will cover all the commercial or traffic activities of the company. Mr. Quirey succeeded the late Mr. Walter Bailey as accountant to the Belfast and Northern Counties Railway. On the death of Mr. Bailey he joined the Midland Railway. On the formation of the London, Midland and Scottish, Mr. Quirey became accountant-general. In his new office he will continue to be in charge of the accounts and will also be responsible for the general administration except for those duties now performed by the secretary and the chief legal adviser—whose office remains unchanged. Mr. Fellows is an old Midland officer, and has been the London, Midland and Scottish chief general superintendent. As vice-president for operation he will be responsible for the working of the railway. To readers of THE ENGINEER the most interesting appointment is that of Mr. Reid, who, the official intimation says, is to have charge of "works and ancillary undertakings, excluding hotels." Mr. Reid was the carriage and wagon superintendent of the Midland Railway, and has filled the same office under the larger company. He has just retired from the Presidency of the Institution of Locomotive Engineers. Presumably he will be in charge of the civil and mechanical engineering departments, the docks and steamboats.

Mr. Baldwin on the Coal Dispute.

A LETTER written by the Prime Minister to Mr. W. H. Carver, which answers the assertion that the Government can provide a ready-made solution of the Coal Dispute, was published a few days ago. Mr. Baldwin informs his correspondent that so far back as July of last year the Government had been endeavouring to secure a settlement which would satisfy both sides, but the difficulty throughout has been the possibility of finding any solution which both sides would agree to accept even as a basis of discussion. He goes on to say: "So soon as it became clear to me that by no effort on our part could we possibly bring the parties together, I made up my mind that I should be deceiving the public, as well as the coal owners and miners, were I to lead them to believe that any further intervention on the part of the Government could in any way help a settlement." He refers then to the fact that an unfortunate notion has prevailed that even at the eleventh hour the Government would step in and would make possible terms of settlement which economic conditions of the industry could not provide. There could, he adds, be no greater mistake. The coal industry must stand on its own feet, and he feels that the hope of further Government intervention merely tends to prolong the dispute. "We should," he continues, "only be paving the way for further misunderstandings were we to pretend that we had it in our power either to compel a settlement, or, in the present temper of the industry, to secure an agreement. We have done all we could, and no wise Government could have done more." To this letter the Prime Minister has added a diary of negotiations which will be found invaluable to all those who require to keep the details of the dispute at their fingers' ends.

Air Transport and the Empire.

SPEAKING at the Imperial Conference on October 28th, Sir Samuel Hoare, Secretary for Air, expressed many interesting views as to the extension of air transport throughout the Empire. He pointed out that at the present time there is no civil air service uniting different parts of the Empire, although a regular civil line between Cairo and Bagdad and Cairo and Karachi is to be established. It will be the first link of the great Empire air service to the Far East, and will reduce the journey to India by seven or eight days. If the Indian Government extended the service to Bombay and Calcutta a further link would be made, and a regular service flight to Australia would come within the region of possibility. An air link with Africa from London to the Cape with branches to the West African Colonies was, he said, in prospect, and in a few months' time a small beginning would be made by an enterprising pioneer who had organised an experimental service of 1400 miles between Khartoum and Kisumu. This "line" would save ten days between Khartoum and Uganda. All these services would be effected by aeroplanes, whilst airships would carry out the long distance non-stop journeys of the future, but if the distant parts of the Empire were to form parts of the chain, they must provide mooring masts and meteorological stations. There were, he thought, no reasons why the journey to Canada should not be reduced to two and a-half days, India five days, Cape Town six days, to Australia eleven days, and to New Zealand thirteen days, by the use of air services. He suggested that before the next Imperial Conference was held it might be desirable to call an Imperial Air Conference.

Port Costs.

THE co-ordinating Committee on Dock Charges, which was organised at the end of 1921 by a number of Chambers of Commerce, Chambers of Shipping, and other important national bodies, has just issued an extremely interesting report on the cost of loading and discharging at British ports. It attributes the greater prosperity of continental than of British ports to improved equipment and to lower costs, and it gives the following striking analysis, which was originally prepared by Sir Frederick Lewis, of how the gross earnings and receipts of steamers are absorbed:—36 days' freight earnings are absorbed by port charges, 115 by stevedoring, 41 by wages, 19 by provisions and stores, 30 by insurance and claims, 35 by repairs, maintenance, commission, brokerage and advertising; 58 by fuel, and 26 by depreciation, thus leaving only 5 days out of a full year for overhead expenses, &c., management, taxation and interest on capital. It is with the first two items, which consume no less than 151 days' freight earnings, that the report is concerned. It gives numerous examples to show that whilst the port dues and charges at continental ports are much higher than they were before the war, yet they are lower than in this country. For example, discharging ore at Maryport took seven days and cost £499, whereas the same cargo was discharged at Rotterdam in one day for a total cost of £280. In another case a steamer of 1860 tons net register, loading cargo and bunkers for Genoa, spent £338 on the Tyne and only £218 at Rotterdam. The reporters say in conclusion:—"We desire to lay stress upon the fact that the relation of expense and speed of handling goods in British ports with that in competitive ports is essentially a question for the mercantile and general community of this country. . . . The facts which have been set out constitute, in our opinion, a *prima facie* case for a complete investigation into the causes of higher costs and diminished services at British ports as compared with continental ports in order that remedies may be found and applied."

Ship Repairing at Southampton.

IT seems probable that the ship-repairing yards at Southampton will be well employed during the coming winter season. Several of the largest liners are to be set aside for routine overhaul and the repair work for the Cunard Company and the White Star Line will make considerable demands upon the repairing staffs of John I. Thornycroft and Co., Ltd., and Harland and Wolff, Ltd., respectively. In view of the amount of work to be done, it has been decided by the Cunard Company to send the Mauretania—which is usually reconditioned at Southampton—to Liverpool. The Berengaria and the Aquitania will, however, remain at the home port. As the Mauretania is scheduled to make a voyage from Southampton on Saturday, November 20th, it is not likely that she will be ready for her lay up in the Mersey before the beginning of December. A certain amount of cabin alteration is to be made, and it is anticipated that the entire re-fit will provide work over a period of from two to three months. The necessary upholstery will be supplied and fitted by the Cunard Company, and structural alterations will be done by Houston's, of Liverpool. The decision of the Cunard Company to carry out this work at Liverpool was influenced, we understand, partly by the apprehension that there might be a shortage of the necessary labour at Southampton, in view of the amount of work to be got through at that port, and partly by the desire to spread out the work so that as many firms as possible might share in the programme of repair work which is to be carried out during the present season.

New Atlantic Liners.

IT is reported that the liner Statendam, which was completed by Harland and Wolff in 1924 as far as the launching stage, is to be transferred from the Holland-America Line to the Red Star Line. When finished the new liner, it is stated, will be run on the latter company's express service between Antwerp and New York as a sister ship to the Belgenland. The Statendam is noteworthy as being the largest ship launched since the war. She has an overall length of 697ft. with a beam of 89ft., and 53ft. 6in. depth, with a measurement of about 30,000 gross tons. At the time of writing the builders are unable to confirm this report, or to say whether the liner will be equipped with steam or oil engine machinery. Another passenger liner which was recently ordered is a twin-screw Swedish-American motor ship, placed with Blohm and Voss, of Hamburg, which will be a sister vessel to the Armstrong-Whitworth built motor liner Gripsholm, described in our issues of November 27th and December 4th, 1925. We understand that the competition for the new liner was exceptionally keen, and that no less than fifteen firms, including six British, three French, three German, two Italian and one Swedish companies submitted tenders. The new liner will have a gross measurement of round about 18,000 tons, and her engines are to be designed to develop about 15,000 shaft horse-power. The engines, it is understood, will be supplied by Burmeister and Wain, and will be of the four-stroke double-acting type, which have proved successful in the Gripsholm.

The Coal Dispute.

THERE is little fresh to add this week to the history of the coal dispute, now in its seventh month. While the miners' representatives are not in contact either with the Government or the owners, there is a certain amount of negotiation proceeding through the agency of a special committee of the Trades Union Congress. That body would appear to be seeking a solution much on the lines of the plan devised and now abandoned by the Government, involving district settlements subject to national agreements, on certain points and independent arbitration in the event of dispute. It remains to be seen whether the miners themselves will consent to accept such a basis of settlement, and also whether the owners will have anything to do with it. On Tuesday the Transport Workers' Federation, the National Union of Railwaymen and other organisations concerned in the transport of coal, held a conference to discuss the institution of the embargo on the conveyance of coal, which the miners so earnestly desire. A final decision on the matter was not pressed, and the conference ended with a diplomatic resolution of a wholly non-committal nature. The conference was no doubt influenced to adopt an attitude which might almost be described as a neutral one by the fact that the National Union of Seamen, one of the bodies taking part in it, had previously balloted its members on the subject, and was in a position to report that for every one in favour of the embargo there were over eleven against it. It was realised, too, that with over a million tons of coal now being produced each week from British mines, an embargo on the importation of foreign coal would not prove effective in holding up the country's industries, but instead would go a long way towards increasing the troubles and difficulties of workers in all trades dependent upon the use of coal. The number of miners at work in the pits producing coal continues to rise steadily. The figure now reached is very little short of the 300,000 mark.

Mr. D. A. Matheson.

AMONGST the changes which have resulted from the reorganisation of the new headquarters staff of the London, Midland and Scottish Railway Company is the retirement of Mr. Donald Matheson, who may be regarded as the *doyen* of chief-officers of British railways. Mr. Matheson has been connected with railways throughout his career, for he served a regular pupilage as a civil engineer and acted as contractor's engineer and agent in the construction of railways in various parts of the country. Thirty-five years ago he was appointed assistant engineer to the London and North-Western Railway. Subsequently he became general manager as well as consulting engineer of the Caledonian Railway, and when grouping was established all the Scottish railways of the L.M. and S. Company were put under his charge. Whilst he was engineer-in-chief of the Caledonian Company, Mr. Matheson directed the design and construction of the Glasgow Central Station extensions, and the Clyde Bridge which carries the approach line to the Central Station. Amongst other important work with which he was connected, mention should be made of the fact that he was resident executive engineer on the construction of the Caledonian Company's Glasgow Central Underground Railway, which for about five miles of its length runs in tunnel under the city and of which the construction presented many engineering difficulties. In 1912 he was appointed a member of the Communication Board attached to the War Office and the Board of Trade, which, it will be remembered, became the Railway Executive Committee at the beginning of the war. At the end of 1916 he, in company with the general managers of certain of the English railway companies, was sent by the Government to France to investigate the requirements of permanent way material for the military railways in the Valley of the Somme. It is of interest to recall that for twenty-eight years consecutively without a break he travelled on every Royal train conveying their Majesties Queen Victoria, King Edward, and King George over the Caledonian section of the line between Carlisle and Aberdeen, as well as on other journeys performed by their Majesties in Scotland. He is a lieutenant-colonel in the Engineer and Railway Staff Corps and a member of several learned societies, including the Institution of Civil Engineers, from which he has received two gold medals.

Drawbridge at Keadby on the L. and N.E. Railway.

THE bridge which forms the subject of this article is the first of its kind to be built in this country. It carries the Doncaster to Grimsby and Immingham main line of the London and North-Eastern Railway, over the Keadby Canal of the Sheffield and South Yorkshire Navigation Company at Keadby, Lincolnshire, and has been but recently completed. It is situated immediately on the east side of Keadby Junction where the branch line to Keadby Goods Yard leaves the main line on the west side of the river Trent, about a mile from the Scherzer Rolling Lift Bridge which carries the London and North-Eastern Railway and the main Doncaster to Frodingham-road over the river Trent. The canal at this point narrows down to a width of 26ft. on the square, but, owing to the skew at which the railway crosses it, viz., 29° 20′, the distance between the abutments along the centre line of the railway is 54ft.

The old bridge, which has been replaced by the drawbridge, was constructed in the year 1866, and was of the swing type. Its roller path and centre pivot were on the north side of the canal, and it swung through an angle of 29½ deg. It consisted of two longitudinal wrought iron main girders of the box type, 104ft. long from the centre of the pivot to the nose, and 152ft. long overall from tail to nose, placed 16ft. apart. The reconstruction of this bridge had been under consideration for some years, cracks having appeared in the castings, both above and below the rollers, no doubt partly owing to defective foundations. The rollers were constantly under water, being situated below the water level in the canal, and that rendered inspection and repairs difficult to carry out. In addition, the increased weight of locomotives using the bridge, beyond what was anticipated when the bridge was originally built, caused high stresses in the members. Only one engine was allowed on the bridge at a time, and there was a speed restriction of eight miles per hour.

In 1913 a scheme was prepared for dealing with the bridge. It was essential that any scheme should provide for:—(*a*) A free opening for the passage of all craft using the canal, a bridge with fixed headway not being allowed; and (*b*) the minimum interference with traffic on the railway during reconstruction, on account of the heavy traffic passing to Immingham and Grimsby.

One scheme then proposed was to construct a lift bridge of the counterbalanced bascule type, and an alternative scheme to reconstruct the bridge on its existing lines, with a bridge of the ordinary swing type of up-to-date construction worked by electric power, was considered. The latter scheme would have necessitated possession of the existing site for a considerable time, and a consequent temporary diversion of the main lines would have involved the temporary raising of the line and the provision of a temporary bridge across the canal with a fixed headway. Owing to the exigencies of the war it was not, however, found possible to proceed with the reconstruction.

In the year 1923, after the grouping of the railways had been effected, the schemes were again considered, and it was then decided to replace the old swing bridge by one of the drawbridge type. The permanent rail level is only 7ft. 6in. above water level, and a bridge of either the bascule type or the swing type would have necessitated the use of parts permanently below water level, which had already proved itself to be a source of trouble in the maintenance of the old structure. Furthermore, the foundations below the pivot of the swing bridge were unreliable, as indicated by the cracks in the cast iron segments above and below the rollers. Hence, in the event of the renewal being carried out on similar lines to the existing bridge, new foundations under the pivot would have been necessary, and their construction would have entailed a considerable increase in the time during which a temporary diversion of the main line was in operation.

The drawbridge ultimately decided upon and herein described fulfils the following conditions:—(1) It was constructed practically complete in a position clear of the existing railway without interfering with the existing bridge or traffic on the railway until the actual removal of the old structure took place, so that no temporary diversion of the main line was necessary; (2) when in position for railway traffic the weight of the structure and superload is distributed over as great a length of the existing walls of the canal forming the abutments as possible, thereby reducing the unit pressure on the existing foundations to a minimum; (3) no part of the bridge structure or machinery is below the level of the water in the canal.

GENERAL DESCRIPTION.

Referring to Fig. 1, it will be seen that the new bridge consists of a framework of ten main steel carrying girders placed parallel to each other 8ft. to 12ft. apart, and in a position at right angles to the canal. These girders are framed together at each end and also transversely along lines 5ft. apart approximately midway along their length. The steel frame thus formed carries obliquely across it four lines of rail

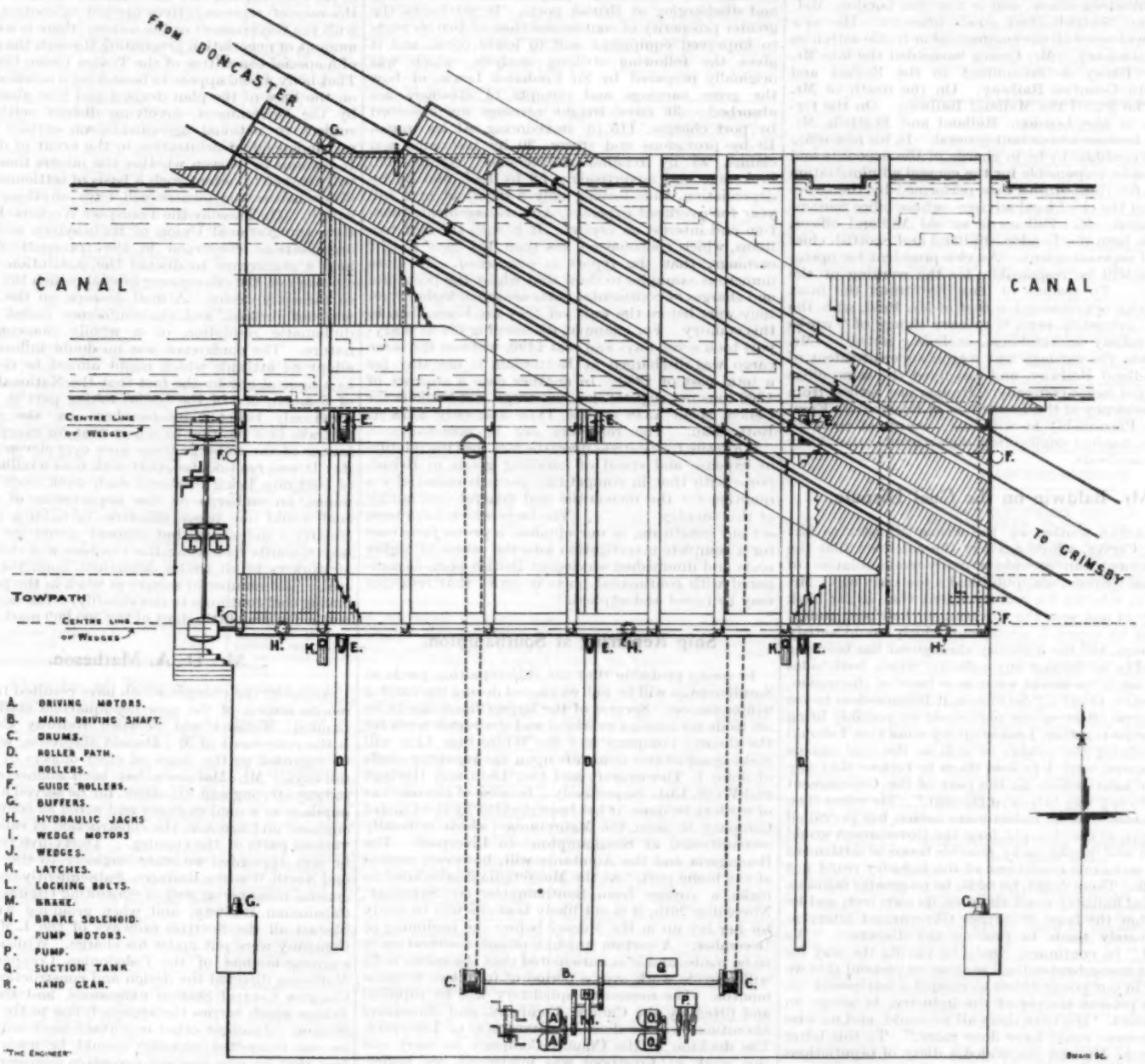

FIG. 1—PLAN OF THE KEADBY DRAWBRIDGE AND ITS OPERATING ARRANGEMENTS

girders housed between the longitudinal girders, which support the two railway tracks. The structure is borne on six steel rollers and travels backwards and forwards in a direction along the line of the main girders and at right angles to the canal on three fixed roller paths. When the bridge is in position for carrying railway traffic the leading ends of the main girders each rest on a fixed bearing on the north abutment, and there are two lines of adjustable wedge bearings, one on the south abutment and one at the tail end, a wedge being provided under each main girder on each line of bearings. Three hydraulic jacks are used for lifting the bridge clear of the roller path to admit of the insertion of the wedges; these jacks are operated at the tail end of the bridge.

Diagrams Nos. 1, 2, 3, and 4, Fig. 2, illustrate the various positions of the bridge. No. 1 shows the bridge in the travelling position and open for river traffic resting on the intermediate and tail rollers, the bridge having a kentledge box at the tail end to keep it down on the tail rollers. No. 2 shows the bridge closed across the canal and still resting on the rollers. No. 3 shows the hydraulic jacks in operation. They lift the bridge off the roller path and tilt the nose of

the bridge on to its bearings on the north abutment. No. 4 shows the wedges inserted and the bridge ready for railway traffic. The rollers are still clear of the roller paths.

The length of travel of the bridge is 36ft. 3in. The bridge was erected on the southern side of the canal, and it was necessary, in order to keep clear of the existing permanent way, to keep it about 28ft. back from its normal position when open. This necessitated a temporary increase in the length of the roller paths over the site of the machinery house.

Foundations.—The existing walls of the canal form the foundations for the bearings of the nose of the bridge on the north side of the canal and of the front line of wedges on the south side, but new foundations had to be provided for the roller paths, back line of wedges, and the machinery house. These foundations were constructed in reinforced concrete and, owing to the unsatisfactory nature of the ground, necessitated a considerable amount of piling.

A reinforced concrete test pile, 14in. square, was driven to determine the length of piles required. The specified set was 1in. penetration for twenty blows of a 2¼-ton monkey falling through 2ft. 6in., the maximum load per pile (inclusive) being 45 tons. The set was reached at a depth of about 44ft., and it was decided to make the whole of the piles 45ft. long, with the exception of those under the machinery house, which were made 42ft. long. It may be of interest to note that, in order to save time, the test pile was made of "Ciment Fondu," which proved quite satisfactory in driving.

There are seventy-two reinforced concrete piles in the foundations, fifty-seven under the three roller tracks and back line of wedges, and fifteen under the machinery house. The piles are 14in. square, reinforced with four 1¼in. diameter bars. The foundations for the roller paths and back line of wedges consist of reinforced concrete beams 4ft. wide and 2ft. 6in. and 1ft. 4in. deep respectively, built over the tops of the piles. The rest of the area over which the drawbridge travels is paved with mass concrete 6in. thick, except under the machinery, where the floor is 2ft. thick. The driving machinery is supported on rolled steel joists supported by the piles and partly embedded in the concrete floor.

Steel Work.—The bridge is designed to carry the British Standard unit loadings and allows for twenty units, and the material is stressed and designed in accordance with the British Standard Specification for Girder Bridges. The load is taken directly by the rail bearers and transferred through the main longitudinal girders to the three lines of bearings on the north and south abutments and at the tail end of the bridge. The general design and construction of the girder work does not call for any special description. The main longitudinal girders are 57ft. long and 4ft. 6in. deep. The two connecting girders, which are fixed 5ft. apart transversely across the main girders and carry the three main rollers, are 91ft. 6in. long and 4ft. 6in. deep. These girders are reduced in depth at three places to provide clearance for the lifting jacks whilst the bridge is travelling.

The rail bearers, generally, are 1ft. 3in. in depth and are attached to the main girders by means of bent plates, the sharp skew of the bridge increasing the difficulty in making these connections. The total weight of steel work in the girder work is approximately 180 tons.

Rollers.—Fig. 3 and Fig. 8, page 491, show the details of the main rollers. There are three cast steel main rollers travelling on three paths, spaced 29ft. 6in. and 16ft. apart. The rollers are 3ft. 6in. diameter, 13in. tread, weigh 3720 lb. apiece, and are designed to carry a load of 80 tons each. They are keyed on to 9½in. diameter steel shafts which rotate in cast iron plummer blocks with gun-metal bearings, 8in. diameter and 12in. long, the blocks being bolted to 8in. by 3½in. steel channels. The main rollers are placed in the 5ft. space between the two lines of transverse girders, which connect the main girders together, the centre line of the rollers being about 32ft. 6in. from the nose of the bridge. The 8in. by 3½in. channels carrying the rollers are connected to the transverse cross-connecting girders by means of a link at one end and an adjusting screw at the other. This arrangement provides a means of adjusting the positions of the rollers in a vertical direction.

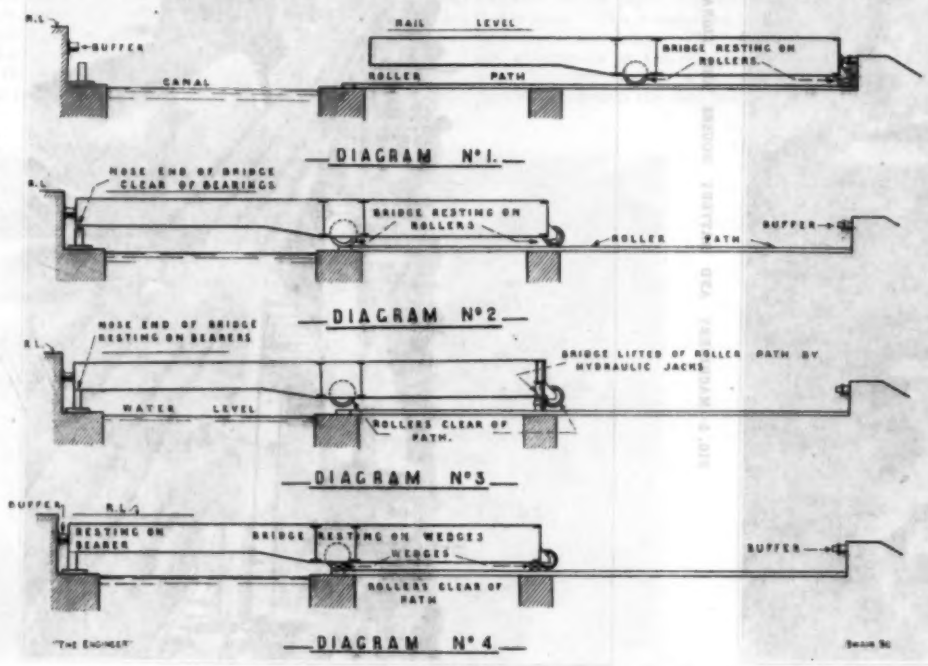

FIG. 2—DIAGRAMS SHOWING DIFFERENT POSITIONS OF BRIDGE

The tail rollers are of cast iron, of similar section to the main rollers, but only 1ft. 6in. diameter, with 6in. tread, and weigh 264 lb. each. They are mounted on a 3in. diameter axle revolving in 2in. diameter gun-metal-lined journals, attached by cast iron brackets to the cross-connecting girders at the tail end of the bridge. The vertical adjustment is made by four 1in. diameter set screws. These tail rollers which are designed to carry the excess kentledge—about 10 tons in all—are shown in Fig. 9.

Roller Paths.—The roller paths are of built-up steel sections, and consist of three vertical webs, ⅜in. thick, and four channels, 10in. by 3½in. by 23 lb., stiffened at 2ft. 6in. centres with ½in. gussets. The base plate, which is bolted to the reinforced concrete girder foundations resting on the piles, is 22in. wide and ⅝in. thick. The top running plate has a machined upper surface, and in the case of the two outside paths is 15in. wide and ⅝in. thick. The centre path top plate is 18in. wide overall, and ⅝in. thick, with ⅜in. raised projections at each side to act as a guide to the centre roller; a clearance of ½in. is given on each side of the roller. The section of the roller paths traversed by the tail rollers only is of lighter section, and the groove in the centre track is narrowed to correspond with the reduced width of the tail roller.

Guide Rollers.—For the further purpose of guiding the bridge, should it get out of alignment, in addition to the guides on the centre roller path, four guide rollers are fixed on either side of the bridge about 3ft. 6in. and 2ft. distant respectively from the centre lines of the main and back lines of wedges. These rollers are of cast iron, 1ft. in diameter, weigh 300 lb. each, and rotate on vertical axle-steel spindles, 3in. in diameter with gun-metal bushes. The spindles are held in cast iron pedestals supported on cast iron brackets bolted to the bed-plates of the adjoining longitudinal girders. To obtain correct adjustments of the rollers, when the bridge is definitely in position, the pedestals can be turned in the supporting brackets about a centre line, having a 2in. throw from the centre line of the spindle and rollers.

Bearings and Wedges.—The bearings of the leading ends of each main girder, ten in number, on the north abutment are taken on a built-up steel distributing girder fixed on the abutment, and set permanently to correct line and level, there being no adjustment of these bearings. At each side of the leading end of the bridge tapered strips are riveted to the bearing plates, against which the sides of the bridge engage when travelling into position, thus acting as guides. The main and back line of wedge bearings on the south abutment and under the tail end of the bridge respectively, ten in number in each case, are carried on continuous cast iron and cast steel bearing plates of box section, supported on the reinforced concrete beams on the top of the piling.

The upper surfaces of these bearing plates are machined for a width of 12in., with side projections to keep the wedges in line. The wedges are of cast steel, 12in. square, 3¾in. thick, with ½in. taper. They are operated by 1½in. diameter rods by screw gearing at the west end of each line of bearings. The gearing is driven by two 2½ horse-power electric motors—one acting as a stand-by—fixed midway between the main and back lines of wedges. A hand drive is also provided in case of emergency.

Lifting Jacks.—The three lifting jacks, one of which is shown in Fig. 9, provided to lift the bridge off the roller paths, are placed along the centre line of the back line of wedges. Each of them has a stroke of 3in., but as the deadweight to be lifted by each varies, the diameters of the rams are 10½in., 11½in. and 13½in. respectively. They are bolted down to the continuous cast iron bearing plates for the wedges, which are carried on the reinforced concrete beam resting on the piling.

The jacks are designed for a working pressure of 1500 lb. per square inch, supplied from a three-throw hydraulic pump working at 95 revolutions per minute driven by two 20 brake horse-power electric motors—one acting as a stand-by. The three jacks are raised or lowered by one double-acting control valve, solenoid-operated.

Hydraulic Recoil Buffers.—Four hydraulic recoil buffers are provided, two on the northern abutment and two at the rear end of the bridge. The cylinders are of cast iron with mild steel rams, 6in. in diameter, working through a 6in. stroke. The working fluid is a mixture of equal parts of water and glycerine. The spring inside the ram is of ⅝in. square section, 4in. outside diameter. The test pressure on the buffers is 900 lb. per square inch.

Latches.—There are two steel latches, 4in. by 2in., fixed in cast iron brackets on the tail end of the bridge, which operate in cast iron catch plates bolted down to concrete foundation blocks. They automatically come into operation on the completion of the travel of the bridge in either direction, and are released by solenoids controlled from the signal-box. These latches and solenoids may be seen in Figs. 9 and 10.

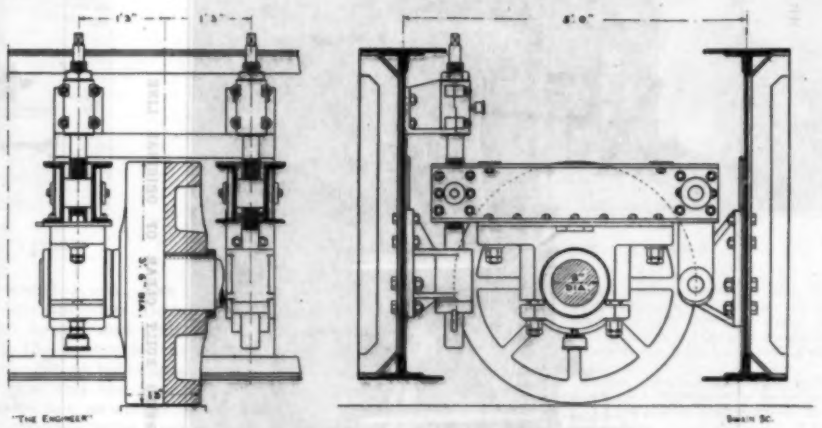

FIG. 8—ARRANGEMENT OF MAIN ROLLER

Locking Bolts.—Two locking bolts of mild steel, 4in. by 3in., are provided, one at each end of the bridge. The bolt at the nose of the bridge is a fixed one, and is situated near the third longitudinal main girder from the west side of the bridge underneath the 6ft. way. This bolt is fixed in position and attached to the main longitudinal girder by two 12in. by 4in. channels. The nose of the bolt is tapered and engages in a casting fixed to the abutment, and ensures the correct alignment of the bridge.

At the tail end of the bridge the locking bolt is movable, and is attached between the easternmost pair of main longitudinal girders, and is operated in a direction at right angles to the travel of the bridge

DRAWBRIDGE AT KEADBY, L. AND N.E. RAILWAY

MR. C. J. BROWN, M. INST. C.E., LONDON, ENGINEER

FIG. 4—BRIDGE BEING BUILT CLEAR OF ORIGINAL LINE

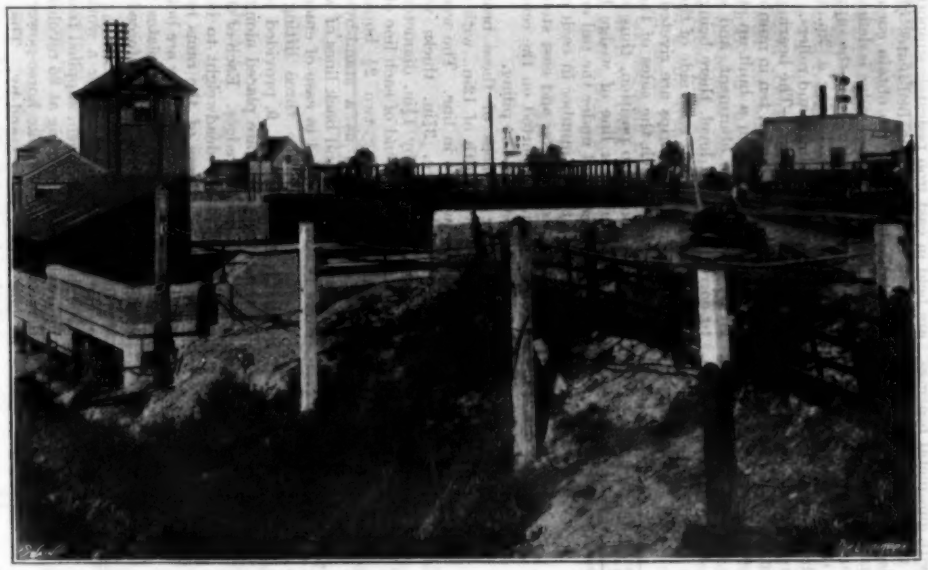

FIG. 5—MACHINERY AND BATTERY HOUSES AND SIGNAL-BOX

FIG. 6—OLD STRUCTURE WITH NEW STRUCTURE IN COURSE OF ERECTION

FIG. 7—GENERAL VIEW OF COMPLETED DRAWBRIDGE

in a position just beneath the outside down rail.

The bolt has a stroke of 9in. and is operated by a screw drive through gearing driven by one 2 brake horse-power motor, 730 revolutions per minute, to which is attached a magnetic brake, the time of operating the bolt being about six seconds. Auxiliary hand gear is attached in case of a breakdown.

The bolt engages in a cast steel housing built into the brickwork at the side of the bridge, in which also is built a chamber for the plunger extension to the locking bolt. This plunger extension, by means of a weighted crank—see Fig. 12—detects the movements of the locking bolt and acts on two limit switches, one of which operates the solenoid which releases the back lock on the king lever in the signal cabin and gives indication that the weighted crank is raised (*i.e.*, the bolt home) and releases the signals. The other limit switch is in series with the jack-raising circuits, which are open in the position "bolt home."

Hauling Gear.—The hauling gear is situated at the rear end of the bridge in the machinery house and is seen in Fig. 11. The whole is supported on rolled steel joists carried on the reinforced concrete piles. The main steel driving shaft is 5½in. in diameter, fixed at right angles to the travel of the bridge and about 6ft. to the rear in its open position at the end of its travel. At each end of the shaft and at 32ft. 3in. centres, are mounted two cast iron hauling drums, each 3ft. 3in. in diameter, on which are wound the wire hauling ropes. The shaft is supported on eight pedestal bearings and is driven through a differential gear in the centre of its length and reducing gear, at a speed of 8·65 revolutions per minute by two electric motors of 35 brake horse-power running at 450 revolutions per minute (one motor acts as a standby). A hand winch to be operated by eight men is also provided.

The main brake operates on the motor shaft and is brought into operation by means of the brake solenoid, which is actuated by means of a screw-operated limit switch.

The whole of the machinery is arranged in such positions and at such levels that it was possible to erect the bridge partly over the machinery, that being necessary in order to clear the existing railway lines, a temporary extension of the roller paths being provided as already pointed out.

Ropes.—The ropes are of steel, 3in. in circumference, and consist of six strands of nineteen wires each of ·061in. diameter; the breaking stress of the ropes is 31½ tons.

One end of each rope is attached to the rear end of the bridge by a suitable steel bracket. The other end passes round a horizontal pulley attached to the cast iron bearing plate of the front line of wedges and back to the steel bracket at the rear of the bridge.

Power Equipment.—There are two batteries contained in the specially built battery house—Figs. 4 and 5, page 490—at the rear end of the bridge. They consist of 60 cells each, and when fully charged have a capacity of 450 ampère hours per battery. They work in parallel for operating the bridge and supply the motors with current at 110 volts for about thirty complete movements of the bridge, in addition to the signalling and lighting load, without recharging. The number of bridge movements averages about nine daily. The batteries are charged from the generators at the company's Keadby lift bridge over the river Trent, a special cable having been provided between the two bridges for this purpose.

New Signal-box.—A new signal-box—Figs. 4 and 5, page 490—has been erected at the rear end of the bridge and contains the main switchboard—Fig. 13—from which the movement of the bridge is operated. From this signal-box the signalling of the main line and the junction to Keadby goods yard is carried out, as well as the control of the public road level-crossing gates near the junction and the wicket gates to the footway and towing path which are carried over the new bridge. This signal-box replaces two which previously were required at the junction and the old bridge. The whole of the bridge movements are electrically controlled, and the operation of the bridge is governed by a master controller of the drum type, fitted with an electro-mechanical lock controlled by the king lever in the signal frame, which prevents the handle being moved until all railway signals are set at "danger." As already pointed out, the king lever is back-locked by the plunger extension to the bridge locking bolt, and as an additional safeguard the correct alignment of the rails at both ends of the bridge is also detected.

Operation of Bridge.

The normal position of the bridge is for rail traffic, the setting of the apparatus for "bridge closed" being "king lever normal, master controller locked, bridge bolt locked." To prepare for opening the bridge the signalman must :—

(1) Ascertain that the track circuits are clear and the facing points at Keadby Junction reversed.
(2) Reverse rail detector levers.
(3) Reverse king lever.
(4) Press "on" push button to close main breaker.
(5) Confirm that supply is at full voltage, 110 or over.

To Open Bridge.—The master controller may be moved right over to the fully open position when all operations will take place automatically and in correct sequence, or the drum may be moved from notch to notch, the action on each notch being as follows :—

Notch 1, Withdraw Locking Bolt.—Starter for bolt motor energised; when bolt fully withdrawn motor is stopped automatically and interlocking circuit completed to Notch 2.
Plunger extension on locking bolt also closes switch in valve solenoid circuit for jack raising interlock.
Indicator shows "Bolt unlocked."

Notch 2, Close Hydraulic Valve and Pump Up Jacks.—Relay energised to energise valve solenoid, which lifts and holds valve in pressure position, whereupon the starter for the pump motor is energised. When the jacks are fully raised the interlocking circuit to Notch 3 is completed by a hydraulic relay and pump continues to discharge through the loaded relief valve.
Indicator shows "Jacks raised."

Notch 3, Withdraw Wedges.—Starter for wedge motor energised. When wedges are fully withdrawn the motor is stopped automatically and interlocking circuit completed to Notch 4.
Note.—The pump will operate during the whole of the wedging movement.
Should a heavy leak or burst occur in the hydraulic system, the pressure relay will fall and stop the movement of the wedges.
Indicator shows "Wedges out."

Notch 4, Open Hydraulic Valve to Lower Jacks.—Relay energised to de-energise the valve solenoid and open valve to exhaust, thus lowering bridge on to track and completing interlocking circuit to Notch 5. The de-energising of valve solenoid also stops pump motor.
Indicator shows "Jacks lowered."

Notch 5, Raise Latches.—Relay energised to energise latch solenoids. When latches are fully raised interlocking circuit is completed to Notch 6.
Indicator shows "Latches raised."

Notch 6, Release Main Brake.—Relay energised to energise brake solenoid. Relays also energised to complete interlocking circuit to Notch 7.

Notch 7, Open Bridge.—Main motor starter energised to haul bridge open. When bridge is half-way over, a limit on the screw limit switch operates and re-sets the latches. When bridge reaches the nearly open position, a limit switch is operated to slow down the motor. When bridge is full open, current is cut off from the motor and the main brake applied.
Gong rings.
Indicator shows "Bridge open."

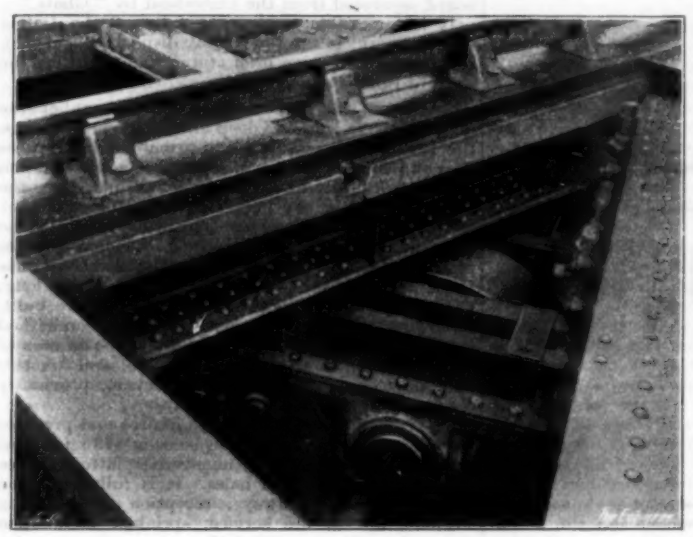

FIG. 8—MAIN ROLLER DURING CONSTRUCTION

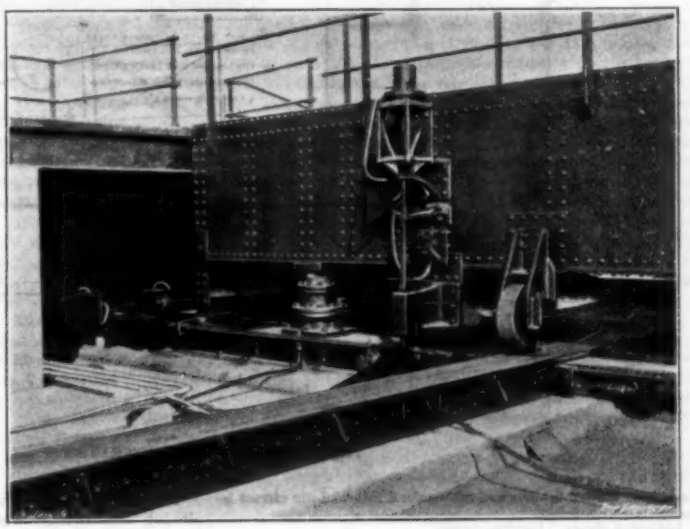

FIG. 9—TAIL END OF BRIDGE SHOWING RAMS, ROLLERS, ETC.

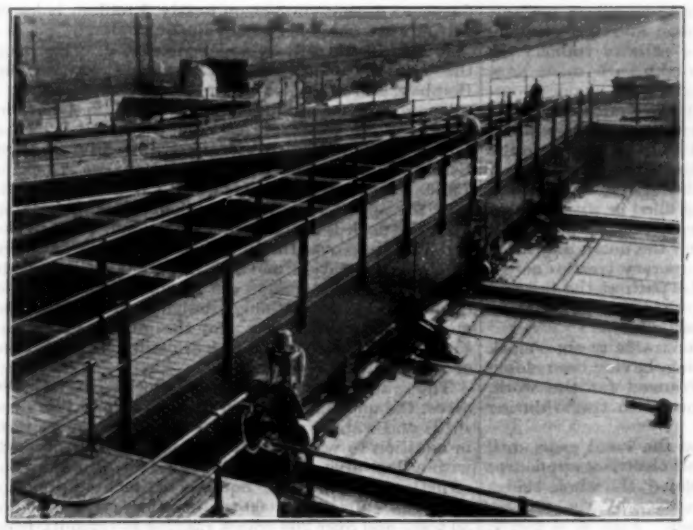

FIG. 10—TAIL END OF BRIDGE SHOWING ROLLER PATHS AND LATCHES

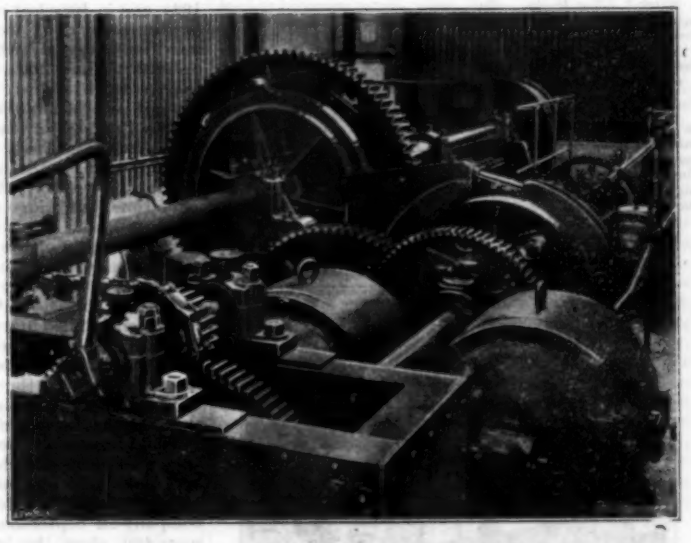

FIG. 11—DRAWBRIDGE HAULING MACHINERY

The controller handle can now be returned to the "off" position.
Press push button to release brakes.

A special time release switch has been provided for emergency use in case of breakdown or derailment of a train on any track circuit controlling normal release of the bridge.

To Close Bridge.—The master controller may be moved right over to the fully closed position, and the pedal switch depressed when the gong rings to indicate the nearly closed position when all operations will take place automatically and in correct sequence, or the drum may be moved from notch to notch, the action on each notch being as follows :—

Notch 1, *Raise Latches.*—Relay energised to energise latch solenoids. When latches are fully raised interlocking circuit is completed to Notch 2.
Indicator shows "Latches raised."

Notch 2, *Release Main Brake.*—Relay energised to energise brake solenoid completing interlocking circuit to Notch 3, as for opening direction.

Notch 3, *Close Bridge.*—Main motor starter energised to haul bridge closed. When bridge is half way over, a limit on the screw limit switch operates and re-sets the latches.
When bridge reaches the nearly closed position, the motors are stopped and the brakes applied.
Gong rings.
When gong rings depress pedal switch.
Brake raised and main motor restarted with all resistances in circuit. Bridge pulled slowly up to the abutment where motor is stalled. At the same time the latches drop into their sockets and energise a timing relay which cuts off power from the motor and applies the brakes in about 5 sec. The interlocking circuit to Notch 4 is also completed when latches drop into sockets.
Indicator shows "Bridge closed."

Notch 4, *Close Hydraulic Valve and Pump Up Jacks.*—Relay

FIG. 13—SWITCHBOARD IN SIGNAL-BOX

energised to energise valve solenoid, which lifts and holds valve in pressure position, whereupon the starter for the pump motor is energised. When the jacks are fully raised, the interlocking circuit to Notch 5 is completed by a hydraulic relay and the pump continues to discharge through the loaded relief valve.
Indicator shows "Jacks raised."

Notch 5, *Insert Wedges.*—Starter for wedge motor energised. When wedges are fully inserted, motor is stopped automatically and interlocking circuit completed to Notch 6.
Indicator shows "Wedges in."

Notch 6, *Open Hydraulic Valve to Lower Jacks.*—Relay energised to de-energise valve solenoid and open valve to exhaust, thus lowering bridge to wedges and completing interlocking circuit to Notch 7.
The de-energising of the valve solenoid also stops the pump motor.
Indicator shows "Jacks lowered."

Notch 7, *Insert Locking Bolt.*—Starter for bolt motor energised. When bolt fully inserted, motor is stopped automatically. Plunger extension on locking bolt closes switch for railway interlock.
Indicator shows "Bolt locked."

The controller handle can now be returned to the "off" position.
Press push button to release brakes.

The king lever can now be restored, when, providing the master controller is in the normal position and the bridge bolt fully home, indication will be received.
The rail detector levers can then be replaced, and will indicate, providing the rails are lineable at either end of the bridge.
Railway working can then be resumed.
The motors for wedges, pumps and hauling gear, for each of which duplicates are provided, are arranged to be used alternatively by changing over every two weeks. In the case of the hauling gear both motors can be used together if required.

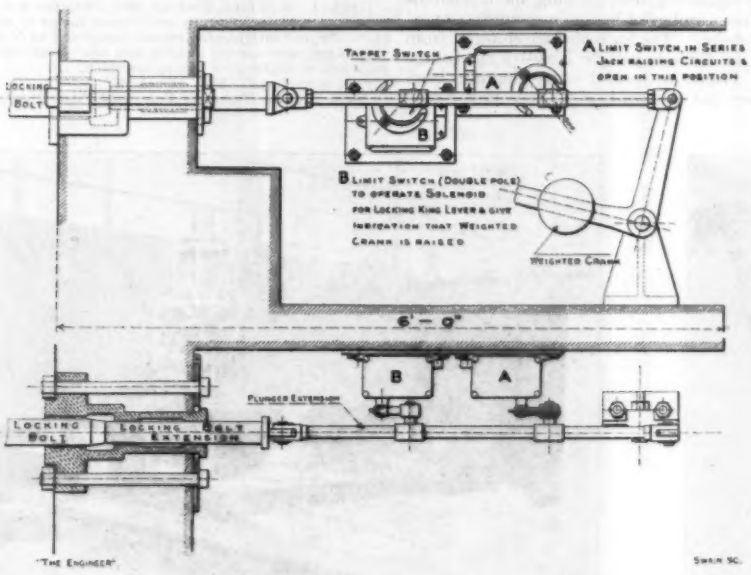
TAPPET SWITCH
A LIMIT SWITCH, IN SERIES WITH JACK RAISING CIRCUITS & OPEN IN THIS POSITION
LOCKING BOLT
A
B
B LIMIT SWITCH (DOUBLE POLE) TO OPERATE SOLENOID FOR LOCKING KING LEVER & GIVE INDICATION THAT WEIGHTED CRANK IS RAISED
WEIGHTED CRANK
5'-0"
PLUNGER EXTENSION
LOCKING BOLT
LOCKING BOLT EXTENSION
"THE ENGINEER"
SMITH SC.

FIG. 12—LOCKING BOLT MECHANISM

The time specified in the contract for opening or closing the bridge was 90 seconds, and the actual time of operation of the drawbridge as completed is 60 seconds.

The contract for the work was let in September, 1924, and in June last was so far advanced as to admit of the removal of the old bridge and the bringing into use of the drawbridge for railway traffic. On Saturday, June 26th, at midnight both main lines were closed to railway traffic, and work at once commenced on the demolition of the swing bridge. This was cut up, by oxy-acetylene flames, into sections, which could be readily handled and removed from the site required for the new bridge. The centre pivot, rollers and roller paths also being removed at the same time, the bridge pit being filled in with precast concrete blocks run with cement, the bearing girder set for the nose of the bridge on the north abutment and the rails supported on temporary trestles across the recess of the pivot and roller path at the tail end of the old bridge, until such time as this could be permanently filled in with ballast.

The line was again opened for traffic at six o'clock on the following Monday morning, having been closed for thirty hours, the time arranged for the work. This being the only interference with traffic during the construction of the bridge.

The bridge was operated by the hand gear until such time as the machinery and electrical appliances and new signal-box were completed, the whole bridge in working order being taken over by the railway company on September 26th last. Figs. 4, 6 and 7, page 490, show the bridge during construction and and on completion.

The drawbridge has been constructed and built to the designs of Mr. C. J. Brown, C.B.E., M. Inst. C.E., chief engineer of the southern area of the London and North-Eastern Railway, and under the immediate supervision of Mr. R. F. Bennett, M. Inst. C.E., assistant engineer for construction. The contractors for the work were Sir William Arrol and Co., Ltd., Glasgow.

Engineering Works in India.*

SINCE I have been associated with India for nearly the whole of my career, it follows almost naturally that the subject of this address should be "Engineering Works in India." In the time at my disposal it is impossible to deal with all, or even many, of the branches of our profession, and I will attempt to deal only with three primary branches of engineering—harbours, railways, and irrigation. Having had some personal experience in the first two of these three important branches of our profession, I am perhaps a little inclined to regard achievements in them more with admiration than with wonder; but of the third I may say that the magnificence of the irrigation works carried out by engineers fills me with wonder and amazement.

* The Institution of Civil Engineers. Presidential address by Frederick Palmer, C.I.E., November 2nd, 1926. Abridged.

HARBOURS.

Considering the enormous extent of the coast line of the Indian Empire, the number of ports with accommodation for vessels alongside quays is surprisingly small. To some extent this is accounted for on the western side by the fact that for nearly a thousand miles, at a little distance from the coast, and stretching southwards from the Gulf of Cambay to Cape Comorin, there is a steep range of mountains, the Sydharis, with summits more than 3000ft. high, which makes access to the seaboard a matter of great difficulty. On the eastern side, between Madras and Calcutta, there is a tract of country, roughly triangular, with a coast base 600 miles long and an area of 100,000 square miles, which is so sparsely populated that there is but little need for a port. Similarly, on the western coast of Burma, there is a length of 500 miles of seaboard separated from the hinterland by "Ghats."

It is impossible to describe fully all the Indian harbour works in the time at my disposal, but it may be interesting to give brief statements regarding the ports of Bombay and Calcutta.

Bombay.—The harbour of Bombay—one of the finest in the world—is a deep arm of the sea, between the island of Bombay and the mainland, 14 miles long and 70 square miles in area. The administration and improvement of the harbour was placed in the hands of the Bombay Port Trust in 1873.

The first work carried out by the Trust was the construction of the Prince's Dock, which was completed in 1883. Between 1883 and 1893 the Victoria Dock and the Merewether Dry Dock, 525ft. long, 65½ft. wide, and 27ft. deep over blocks, were built. Following upon these works, the Trustees embarked upon a large reclamation scheme by which an area of nearly 600 acres was made available, and on this land now exist large depôts for cotton, previously dealt with in the heart of the city.

The cotton depôt is 127 acres in area and provides accommodation for 1¼ million bales in 178 reinforced concrete warehouses, and uncovered platform space for a further 1 million bales. It is fully equipped with roads and railways, reception and loading stations, offices, fire service, sprinkler installation and salvage stations, and there is ample room for further extensions. The total cost was £1,220,000. As many as 27,000 bales have been dealt with in a day, and during one season nearly 3 million bales of cotton were unloaded at the depôt.

A Port Trust railway was constructed, connecting the docks with the two main lines of railway serving Bombay, and is worked by the Trustees.

These works were finished in 1913, and, in the meantime, the Alexandra Dock was constructed and a further reclamation made, known as the Ballard Estate. The entrance to the Alexandra Dock is 750ft. long and 100ft. wide, with a depth of 41ft. over the sill at high water. Alongside and opening from the dock is a dry dock 1000ft. long, 100ft. wide, and 36ft. deep over the sill. Just outside the entrance is a railway station and the Ballard Pier, alongside which the mail steamers are berthed on arrival and before departure. Although designed and commenced more than twenty years ago, the governing dimensions of this fine dock and pier are still well in advance of requirements.

The water area of the three docks exceeds 100 acres, the quayage is 23,500 lineal feet, and there are sheds and warehouses covering 3,200,000 square feet, in addition to which a new three-storey transit shed, with a floor area of 140,000 square feet, is under construction. The crane equipment includes one of 100 tons capacity, a 60-ton floating crane, one of 30 tons, and over 200 cranes ranging in capacity from 6 tons to 30 cwt.

In addition to the three docks there are numerous wharves and basins for traffic carried by country craft and sailing vessels. A surprisingly large trade is carried on in these old-fashioned boats, and I have no doubt they will continue to ply for all time.

A depôt for petrol and kerosene, situated near Trombay, at the head of the harbour, was constructed at a cost of £600,000 and opened in 1922. A deep-water channel had to be dredged to the bulk oil pier, and for this and other improvements and for maintenance of existing channels, the port possesses a dredging fleet consisting of nine large modern dredgers of various types, nine steam hopper barges, and a rock-breaking plant.

During the war the accommodation of the port was utilised to its fullest capacity by the naval and military authorities. More than 4000 transports and hospital ships were berthed, 2,250,000 tons of military stores were handled, 1,627,000 troops and *personnel* were embarked or disembarked, and, in addition, 243,000 sick and wounded.

At the present moment the Trustees have under consideration the construction of very large new docks farther up the harbour at Trombay, the total cost of which, when completed, may amount to nearly £20,000,000.

Calcutta.—The city and port of Calcutta are situated on the left bank of the river Hooghly, some 80 miles from the sea. In 1848 a Government Committee

recommended the construction of docks at Kidderpore, with provision for vessels "of an average burthen of 400 tons," but up to the time of the creation of the Calcutta Port Trust in 1870 the only berths for vessels consisted of four small tee-headed jetties on the riverside, equipped with cranes and sheds. The construction of an enclosed dock was commenced in 1884 at Kidderpore, about 3 miles below the jetties. The works comprised an entrance lock, 400ft. long and 60ft. wide, entering into a tidal basin 600ft. square, from which there was separate access to the river through an 80ft. entrance with a single pair of gates.

No. 1 Dock, 2750ft. long and 600ft. wide, with twelve berths, was opened in 1892, and thereafter Dock No. 2 has been proceeded with as required. The entrance lock has also been lengthened, by means of inner and outer caissons, to 510ft. There are sheds with floor area aggregating over 1 million square feet, for the storage of grain, and two large warehouses of four storeys in which 4,500,000 lb. of tea can be stored.

In 1906 it became apparent that further extensions of the dock accommodation would be required in the near future, and a scheme was prepared under which a site, some 1750 acres in area and with a deep-water frontage to the river of over 3000 lineal feet, was then acquired for future developments. The scheme included two entrances from the river, a dock 2400ft. long and 1000ft. wide parallel to the river, and two branch docks, 5750ft. long and 800ft. wide and 5900ft. long and 600ft. wide respectively, one at either end of the main dock. The total water area of the ultimate development was to be nearly 200 acres.

The taking up of land for dock and railway works in India is a compulsory acquisition by the Government, the compensation to owners being based on the value at the date on which the land is notified in the *Gazette* as being required for public purposes. It is therefore a matter of some importance, especially in the neighbourhood of large cities, to maintain the utmost secrecy in the preparation of proposals involving land purchase, in order to avoid exploitation in values. The preparation of the scheme was consequently carried out in my own house, and the gazetting of nearly 3 square miles around the southern and eastern sides of the city came as a great surprise to Calcutta.

Beyond the acquisition of the land nothing was done for some years, but extensive works are now in progress. An entrance lock, 700ft. by 90ft., two dry docks in tandem, 590ft. and 575ft. long respectively and 80ft. wide, and a short length of quay wall affording berthage with 35ft. of water for five vessels, will be completed in 1928 at a cost of £5,500,000. Concurrently with this work a new entrance to the older docks, 580ft. long and 80ft. wide, is under construction. Five jetty berths have also been built in the river, between the docks, with a low-water depth of 40ft., four with double-storey transit sheds for general produce, and one for coal loading.

The dangers and difficulties of navigating the river Hooghly were so notorious that a River Conservancy Department was organised and has been brought to a high state of perfection. Such were the dangers of the river in early days that in 1830 the maximum draught was limited to 20ft.; it increased in 1860 to 23ft., in 1870 to 24ft., and in 1880, when steam vessels began to use the port more frequently, the limit was extended to 25ft.

In 1907 a large suction dredger was purchased to operate on the bars, and since then two more such dredgers have been added. By the use of this dredging plant and the aid of the admirable survey organisation the maximum draught was increased by 1925 to 30½ft. The pilotage waters of the Hooghly extend for 120 miles from Calcutta.

The total quayage at the jetties and docks for ocean-going vessels is at present 20,610ft. in length, and the equipment of the berths includes one 100-ton shear legs crane, one 60-ton floating crane, one 30-ton floating crane, one 20-ton floating crane, two breakdown cranes of 15 and 20 tons, a 30-ton goliath crane, a 10-ton crane, and over 250 cranes of from 30 cwt. to 5 tons capacity. There is also extensive berthage for inland vessels, and the Commissioners maintain a very successful steam ferry service up and down and across the river.

The main railways entering the port are the East Indian, the Eastern Bengal, and the Bengal-Nagpur, but the actual distribution of traffic is undertaken by the Port Trust over its own railway, which extends some 6 miles along the river side on the Calcutta bank and for about 2 miles on the opposite side.

Railways.

The history of railway construction in India may be said to commence in 1844, when a proposal to build the East Indian Railway was first made. Actual construction was not begun until 1850, and at about the same time works were started on the Great Indian Peninsula Railway. By the end of 1879, 6128 miles had been constructed by companies at a cost of approximately £97,872,000 and 2175 miles by the State at a cost of £23,695,226.

Following upon a disastrous famine in 1878 and the report of a Famine Commission in 1880, a more vigorous policy of construction was adopted and the company system was again reverted to.

Further construction was carried out by State agency, and by 1900 the total mileage had reached 25,072 route miles, of which 13,994 miles were of the original standard gauge of 5ft. 6in., 10,389 miles were of metre gauge, and 689 miles of smaller gauge.

The policy of gauge has been the subject of much criticism and discussion, but whatever the merits may be, it is undoubtedly true that both standard and metre gauge have come to stay; and it is equally true that both serve useful purposes, the former for densely populated districts with heavy traffic and the latter for less density of traffic.

The construction and development of railways has been much handicapped by the fact that the State, being owner of most of the railways and predominant partner in the remainder, merged the railway revenue and expenditure in the general accounts of India. New capital had either to be found by the State or raised on a Government guarantee, and the amount available fluctuated with the borrowing power of the State and with other demands of the country. Again and again it was found necessary to suspend construction and defer improvements for reasons entirely unconnected with railway administration. In 1922, however, partly as a result of recommendations made by the late Sir W. Acworth's Committee, and partly because the disastrous results of this policy of financing became so obvious in the inefficiency and practical insolvency of the railways at the close of the war, the Government secured the approval of the Legislative Assembly to a vote of 100 millions sterling, spread over five years, for capital expenditure. At the same time a reorganisation of the Railway Board, the managing agency under the railway member of the Viceroy's Council, was put in hand, and a Chief Commissioner was appointed to preside over the Board. The new Board undertook many widespread reforms in organisation and working, and in 1924 the Legislature accepted proposals made by them for the separation of railway finances from the general finances of the country. It is unnecessary to enter into details of this measure, but briefly it may be said that the State-owned railways are under an obligation to pay a contribution to general revenues of 1 per cent. on the total capital after meeting all interest charges. The balance of profits is divided, according to a prescribed formula, between general revenues and railway reserves. A depreciation fund has also been instituted, to which annual contributions are made, based on the assumed life of all wasting assets, from which appropriations are made for renewals as they become necessary. The result of this change has been that general revenues are relieved of the risks of fluctuations in railway profits, and the Railway Board can carry out the work of development and improvement according to pre-arranged plans. They have consequently been enabled to develop a more progressive policy of new construction and have laid out a programme which will result in the addition of about 1000 miles of new railways per annum. Work on this programme is now being vigorously pushed forward in all parts of the Indian Empire.

Apart from the railways built for commercial purposes, there are others primarily constructed for protection against the results of famine; and again, in the extreme north-west, there is a large mileage of strategic railways, on which the expenditure has reached the huge total of 23¼ millions sterling, because, generally speaking, they traverse extremely difficult country. The construction of the Khyber Railway was described and illustrated in papers read during last session, and this line may be taken as an example of some of the worst difficulties experienced in making the strategic railways.

In our own country the bridges carrying railways over large rivers are comparatively few, the Forth, the Tay, and the Severn bridges, and the bridge over the Menai Straits, being the only ones of outstanding importance. In India, rivers of the first magnitude are encountered. The Nerbudda, the Tapti, the Indus, the Jhelum, the Chenab, the Ravi, the Beas, the Sutlej, the Jumna, the Sone, the Hooghly, the Ganges, the Godaveri, the Kistna, and the Cauvery are all mighty rivers, and most of them have been crossed several times. There are in all nearly a hundred railway bridges over 1000ft. long between abutments, of which twelve exceed 4000ft. in length. The longest is the Upper Sone, over 10,000ft. in length, but pride of place must be given to the bridge over the Ganges at Sara. This bridge crosses the river 1300 miles from its source and consists of fifteen main spans of 345ft. The foundations are of wells, or monoliths, sunk to the astounding depth of 160ft. below low-water level.

The cantilever bridge over the Indus at Sukkur, with 790ft. clear span, was at the time it was built the longest cantilever bridge in the world, but since then it has been entirely eclipsed by the Forth and Quebec bridges.

It is impossible to give, within the compass of this address, anything approaching an adequate description of the railways of India, but enough has been said to show that the engineering works accomplished by this branch of our profession—accomplished, too, in the earlier days, in a comparatively unknown country, and throughout with but little of the plant associated with large works in England—compare very favourably, both in boldness of design and in low cost, with railway works anywhere in the world.

The Government have always had general control over rates and fares. In the case of company-managed railways the contracts provide for the fixing of maxima and minima rates by Government, and these are similarly applied to the State-managed railways. The various railway administrations have a free hand to fix rates within the maxima and minima. There has, however, always been a tendency, amounting to a definite policy on some railways (in particular the East Indian and the Bengal North-Western) to reduce rates and fares to as low a level as possible, with the object of securing a reasonable return rather than high profits on the money invested. The extension of State management and the separation of railway finances from the general finances has given a fresh stimulus to this policy. As the return required from the State property—namely, 1 per cent. over the actual interest charges on the loans involved—is now stabilised, there is an obvious incentive to increase the scope of railway business as far as possible, consistently with securing this return. There can be no doubt that this policy has been of the greatest benefit to India and has brought to the railways an immense amount of traffic which would not have been available for transport at higher charges.

Some of the railways, notably the East Indian, the Bengal-Nagpur, and the Great Indian Peninsula, own and work their own coalfields, from which over two million tons of coal—or one-third of the total railway requirements—were raised in 1924-25. At most of the fields coal is obtained in the manner usual in this country, by sinking pits, but in some instances coal is obtained from open quarries, for instance, in the Bokharo coalfield, where the three railways named work a seam of solid coal 75ft. thick, excepting for a stone band about 15in. thick. The overburden, in places 40ft. deep, is removed and dumped in the area from which coal has been extracted, and the coal is removed in two stages, above and below the stone band.

Irrigation.

The need for irrigation works in India has arisen from the extremely varied meteorological conditions which prevail in that country. Normal rainfall varies from nearly 500in. per annum at Cherrapunji in Assam to less than 3in. per annum in Upper Sind, while the maximum has reached over 900in. per annum at the first-named place and the minimum nil in Sind. Another factor is the unequal distribution of the rainfall. In the south-east of the Peninsula the heaviest rainfall occurs in the three months October to December, but elsewhere precipitation is confined almost entirely to the south-west monsoon period, June to October. In the winter months 1in. or 2in. normally fall, but in the hot season, March to June, there is practically no rainfall.

The problem is to conserve, store, and distribute the rainfall in such tracts as admit of this procedure. But by far the greater part of the country, east of the Sydharis, or "Ghats," of Western India, is a high-lying rocky plateau subject to uncertain rainfall and having rivers which, for the greater part of the year, are nearly dry. The whole area is very unfavourably situated in this respect, and although by the construction of tanks or reservoirs some benefit is obtained, the greater portion of this central plateau must remain for ever unirrigated.

In Northern India, however, there is a huge area of territory watered by rivers which rise in the Himalayas, and as these are fed by melting snows in the hot season there is always a supply of water, reliable within limits, which has been harnessed for distribution. The Indus and its tributaries, the Jhelum, the Chenab, the Ravi, the Beas, and the Sutlej, flow in a south-westerly direction, while the Ganges and its main tributary from the Himalayas, the Jumna River, flow south-easterly. All these rivers have been brought into use, and their canals command large areas in the Punjab and the United Provinces.

But with all these works only about 11 per cent. of the cultivable land in India is irrigated by canals, about 5·3 per cent. from wells and 6·2 per cent. from reservoirs, mainly in the Madras Presidency, leaving 77½ per cent. unirrigated.

The history of irrigation in India extends back through the centuries beyond the commencement of the Christian era. Wells have been used from time immemorial, and in Southern India tanks or reservoirs have existed for centuries. The drawing off of flood waters from some of the large rivers by means of inundation canals was practised in very early days, and traces are found of channels which have for ages been buried in forest growth.

The first work by British engineers in India was the reopening of the Western Jumna Canal in 1821. From want of sufficient funds this undertaking was not a success at first, but mistakes then made were corrected one by one until it became a very flourishing concern.

In 1834 Colonel (afterwards Sir) Arthur Cotton put forward proposals for establishing a stable *régime* in the Cauvery, where accumulations of silt had jeopardised the utility of those ancient works; and, with the exception of some mistakes which have since been rectified, these proposals proved effective.

Commenced in 1842 and opened in 1854, the Ganges Canal in the United Provinces was the first work wholly constructed by the British in India. It was proposed, designed, and built by Colonel Sir Proby

Cautley, of the Bengal Artillery, and still ranks as one of the largest in the world, serving in many respects as a model for those since built.

In 1846 the Godaveri Weir was built. It is in four sections, separated by islands, with a total length of more than 2 miles, and the canals drawn from the impounded water have converted the Godaveri delta into one of the richest tracts in the Madras Presidency. This was followed by a project of almost the same magnitude on the river Kistna, and several minor schemes in the same Province.

The Upper Bari Doab Canal, in the Punjab, commenced in 1851, was on a somewhat smaller scale than the Ganges Canal, but it serves to irrigate 1¼ million acres.

Following upon this successful activity there was a "boom" in irrigation. Sir Arthur Cotton put forward several schemes, which included great canals connecting for navigation Madras with Poona and Bhatkal on the west coast, with arms stretching northwards to Ahmadnagar and southwards to Mangalore. A somewhat similar project was started in Orissa, with a high-level canal connecting Cuttack with Calcutta, which was eventually to be carried to Cawnpore and even Karachi, and connected up with the Madras-Bhatkal system.

Sir Arthur Cotton's ability, undoubted as an engineer, did not extend to the realms of finance; but blinded by the magnificent results obtained in his earlier works, both the authorities and the public lent their aid to the formation of companies to embark upon these huge projects, all of which ended in disastrous failure and in the Government having to buy out the companies.

This experience led to the adoption in 1866 of the policy of Government loans for productive works, and the great development of irrigation works in India which has taken place since that time has followed upon the acceptance of this policy.

Five great works were inaugurated—the Sirhind, the Lower Ganges, the Agra, the Lower Swat, and the Mutha canals, and several smaller works. The Sirhind Canal draws its waters from the river Sutlej and commands 8500 square miles, 4000 of which are in British territory and 4500 in Indian States, mainly Patiala. By agreement between the Government and the Indian States concerned the capital cost was divided between the parties in proportion to the areas served. The total length of the channels in this canal system is 3733 miles, being exceeded only by those of the Upper and Lower Ganges Canals, which are 3861 and 3796 miles respectively. The area irrigated is 1,600,000 acres, and on the British portion a return of 11½ per cent. on the capital expended is realised.

The Lower Ganges Canal system includes a weir 3800ft. long across the Ganges at Narora. It is fitted with falling shutters, which enable the level of the normal cold-weather supply of the river to be raised by 10ft. to feed the canal. This canal joins the original Ganges Canal, now usually known as the Upper Ganges Canal, at Gopalpur, and has relieved that canal of a considerable amount of irrigation.

The Agra Canal takes off from the Jumna River just below Delhi, where a weir ½ mile long impounds water 10ft. above the river bed level, with shutters to hold up a further depth of 3ft. It is a comparatively small system, irrigating some 300,000 acres.

The construction of the Lower Swat Canal was prompted mainly by political motives, in the hope that the existence of such a work would tend to pacify and settle the Mohmand Border at the extreme limit of British India beyond Peshawar.

It was built under the greatest possible difficulties, in a country barren and almost uninhabitable, while about it lay an inhospitable land peopled mainly by predatory marauders. Opposition was experienced from the tribes immediately beyond the frontier, while the people within British borders were for a long time either openly or passively hostile. Military guards had to be employed for the protection of all workpeople, and every engineer's bungalow was a fort, guarded at night by sentries, and from which no one ventured after dark. The canal head is formed by a reef which runs across the river, 2 miles above Abazai Fort, but subsequently a weir was built at Abazai.

Although originally estimated to serve 24,000 acres, the system became so popular, when once its advantages were perceived, that the irrigated area was extended to over 160,000 acres, and yields a return of 10 per cent. on the capital outlay.

The last of the five main schemes referred to is the Mutha Canals projects in the Bombay Presidency. It consists of a dam across the valley of the river Mutha, some 10 miles above Poona, about 1 mile long and 100ft. high above the river bed, with a canal on either bank. The main purpose of the canals was to afford a plentiful supply of water to Poona and to Kirkee, but, incidentally, irrigation is afforded to 25,000 acres. The works, commenced in 1869, were completed in 1879.

There was no previous experience of a dam of this magnitude to draw from, and in honour of Colonel Fife, of the Royal Engineers, who designed the works, the impounded lake has been named Lake Fife.

There is probably no part of India more favourably situated in regard to rivers and more unfavourably in regard to rainfall than the country already referred to, lying between the Jhelum and the Sutlej rivers. This tract is traversed by the five great rivers from which the Punjab proper takes its name—the land of the five rivers. They are the Jhelum, Chenab, Ravi, Beas, and Sutlej. The rainfall is scanty, by far the greater portion of the country having a precipitation of less than 15in. per annum, and much of it less than 10in. Even these small rainfalls are liable to serious deficiencies in years of drought, and excepting some small cultivation on the fringes of the rivers, the whole vast stretch of country was formerly desert waste, with no resident population beyond a few nomad graziers.

Prior to 1880, with the single exception of the Swat Canal, the main object of canals was to improve existing cultivation, but in the Punjab the problem confronting the Government was not only to turn desert waste into cultivable land, but also to transport bodily whole communities into the new areas thus opened up.

The success attending this work encouraged the Government to proceed on a far greater scale, and in 1889 the Lower Chenab Canal project, the most extensive and successful irrigation system in India and probably in the world, was taken in hand. The tract to be served was one of extreme desolation, yet this wilderness has been converted into a veritable garden.

The weir across the Chenab is 4090ft. long, and the main canal, with a width of 250ft., carries a discharge of 10,700 cubic feet per second, six times that of the Thames at Teddington.

Colonisation commenced in 1892, and the earlier colonists had an even harder time than on the Sidhnai system. There was no railway, and they had to walk through a country nearly as waste as that to which they were going. The same opposition was met with from the indigenous nomads, and many prospective settlers, refusing to believe that the land was worth cultivating, returned to their homes. Cholera also created havoc, but although those who persevered were rewarded by an excellent crop, their troubles were not over. There was insufficient labour to harvest the crops, and difficulties were encountered in disposing of what could be reaped, as all surplus produce had to be carried along the same perilous way by which the settlers came. This was, however, only a transitory phase, as news of the fertility of the soil and the magnificent crops spread quickly over the Province, and the principal difficulty became the selection of desirable settlers from the thousands of applicants. Roads and railways came rapidly into being, towns and factories sprang up, and in ten years the population rose from 8000 to 800,000.

The capital cost was just under £2,500,000, which yields a return of 45 per cent. per annum, while the value of the crops in the year 1919–20 was no less than £12,000,000.

The Periyar project in Madras is a remarkable instance of directing the resources of Nature to the service of mankind. The Periyar River rises in unsurveyed country in the Western "Ghats" in Travancore, and flows through uninhabited jungle westwards to the Arabian Sea, while the country lying east of the "Ghats" was in a continual state of famine. Across a steep V-shaped gorge, some 3000ft. above sea level, in the middle of almost impenetrable malaria-ridden jungle, a concrete and masonry dam has been constructed under difficulties, both engineering and climatic, never before encountered. The height of the dam is 173ft. above the river bed. Its length at foundation level is only 200ft., increasing to 1240ft. at the crest. Nearly 50ft. below crest level a channel is led through a deep cutting for over 1 mile towards the summit of the range, and through the summit a tunnel over a mile long has been bored, carrying the waters into the eastern watershed where they are led into the river Vaigai. A weir across this river, nearly 100 miles lower down, gives access to the Periyar Canal, with 250 miles of main canal and distributaries.

The difficulties experienced on this work were enormous. The nearest railway station was 90 miles away. Rainfall from June to November was practically continuous, and at other times sudden floods, rising to 120,000 cubic feet a second, were frequent. There was no possibility of diverting the river from the gorge, so that every flood had to be passed over the unfinished work. Labour was difficult to obtain, and far more difficult to keep, owing to the unhealthiness of the district. In June, 1895, the hospital attendances reached the appalling figure of 1465 per thousand labourers employed.

The total quantity of water impounded to crest level is 15,660 million cubic feet, and of this quantity, owing to the wedge shape of the gorge, over 9000 million cubic feet can be utilised, being above the outlet level. By this work a river ordained by Nature to flow into the Arabian Sea has been led across the Peninsula into the Bay of Bengal, irrigating in its way some 100,000 acres of land.

The Triple Canals project in the Punjab is the largest irrigation work yet completed in India, and is a striking monument not only to the engineering skill of those entrusted with the design and execution of the work, but also to the far-sightedness of the originators of the scheme. The main object was the irrigation of a tract known as the Lower Bari Doab, between the Ravi and the Sutlej, and as the winter waters of the Ravi were already fully utilised by the Upper Bari Doab Canal, the Sutlej seemed to be the natural source of supply. A scheme for a canal from this river was actually formulated, but it was strongly opposed by the Settlement Commissioner, Sir James Wilson, and by Colonel Jacob, of Chenab Canal fame, on the grounds that the Sutlej waters would eventually be required for development of irrigation on either side of that river, and that as there was a large supply in the Jhelum in excess of the requirements of the watershed lying between it and the Chenab, this surplus should be utilised for irrigating the Lower Bari Doab.

In the surmounting of engineering difficulties the construction of the Upper Jhelum Canal was exceptional. The natural weir rises 69ft. above the canal bottom, and the canal, with a bed width of 220ft., runs for the first 1500ft. through the "Mangla Cut," which has a maximum depth of 110ft. of excavation. For over 60 miles it follows along the slopes of the Pabbi Hills, passing in quick succession through deep cuttings and over high embankments, crossing no less than sixty drainages from these hills. In the case of the large crossing of the Suketar the canal is taken into the torrent bed, where a barrage, 1600ft. long, fitted with thirty-three bays of 40ft. lift gates through which floods can be passed, directs the water to the farther side, and it is re-admitted into the canal through a regulator with seventeen bays of 20ft. The works in this canal include 50 million cubic yards of earthwork and 1,250,000 cubic yards of concrete and masonry.

Following a course almost due south, the Upper Chenab Canal throws out a branch to the right and to the left, and eventually crosses the Ravi 120 miles from Merala. The crossing of the Ravi at Balloki by means of a level crossing is an enormous work. There is a barrage 1650ft. long, with thirty-five gates of 40ft., to pass the Ravi discharge of 150,000 cubic feet a second, and, on the left bank, a regulator having fifteen bays of 20ft. forms the headworks of the Lower Bari Doab Canal, the third system of the project. At the crossing the Ravi River is paved with an impervious floor, stretching for over 200ft. upstream and 110ft. downstream.

The project was sanctioned in 1905, and in originality of conception and design and the boldness and magnitude of the works undertaken, the Triple Canals rank as one of the finest engineering works in the world. Each section was opened as it was practically finished, the first in 1912, the third in 1913, and the second in 1915, but the whole work was not completed until 1917. There are 433 miles of main canals and branches, 3010 miles of distributaries, and nearly 20,000 miles of watercourses, irrigating 1,750,000 acres out of a total area commanded of almost 4 million acres, or 6250 square miles, of which 1,570,000 acres (some 2500 square miles) was waste land. From Mangla on the Jhelum to the southern extremity of the Lower Bari Doab is a distance of nearly 500 miles.

The total cost was about 8 millions sterling, and, besides the vast indirect benefits resulting from the scheme, a direct return of 8 per cent. on capital will be obtained when the lands are fully settled.

Of the many works in progress, space only permits of briefly mentioning four.

The dam across the Pravara at Bhandardara, in the Bombay Presidency, will be 270ft. high and impound about 13,000 million cubic feet of water.

The Bhatgarh Dam, also in the Bombay Presidency, will be 190ft. high and more than a mile long at the crest, impounding over 24,000 million cubic feet of water.

The Sind Canals works include a barrage across the Indus at Sukkur, 4725ft. long, with sixty-six spans of 60ft., each supporting a shutter of that length, and 18½ft. high.

The Sutlej Valley project is the direct outcome of the Triple Canals scheme. The cost is estimated at £11,000,000, and a net return of 12 per cent. is expected from water rates alone. The principal virtue of the project, however, lies in the fact that 3,750,000 acres (5500 square miles) of land, at present desert waste, will be brought under cultivation, and, including the enhancement in land value, the return on the project will amount to 38 per cent. per annum.

Norwich Electricity Supply.

THE electricity supply of Norwich was started by a company in 1893, and was acquired by the Corporation in 1902. For many years, distribution was carried out from a station in Duke-street, but the full capacity of that station having been reached, the Corporation decided in 1922 to erect a new station at Thorpe, on the east side of the city, and between the river Wensum and the railway sidings. This station was officially opened on Thursday, October 28th last. The plant consists of two 5000-kilowatt turbo-alternators running at 3000 revolutions per minute, giving three-phase current at 6600 volts 50 cycles. A similar set which is now at Duke-street will be transferred to the Thorpe Station early next year. The turbine house is big enough to accommodate a fourth set, which will probably be one of 10,000 kilowatts, and it is estimated that the ultimate full capacity will be about 50,000 kilowatts. The circulating water is drawn from the river at the west or upstream end, and returned at the lower end about 130 yards away. The boilers, four in number, are

of the Stirling type, with something over 6000 square feet of heating surface, and capable of evaporating normally 40,000 lb. of water per hour. Two of them have Underfeed stokers and the other two Erith-Roe stokers. The working pressure is 250 lb. per square inch, and the total temperature 650 deg. Fah. Induced draught is employed, and the two short chimneys are barely visible over the top of the building. Forced draught fans are also provided. Coal is brought to the station either by rail or water, a Telfer track being employed to deliver it direct into the boiler-house. The ashes are removed by two lines of water trough conveyors, which deliver the ashes up inclined planes to bunkers outside the building. The condensate from the turbine is heated by steam bled from the turbine to about 150 deg. Fah., and further to approximately 212 deg. by exhaust steam from the feed pump. The make-up water is freed from air as well as from impurities in a Cracho and Bouillons evaporator. It is taken from the river to an open storage tank on the economiser floor, and after treatment in the evaporator passes to a closed tank, whence it flows to a hot well tank. It is the intention to close down the Duke-street Station for the generation of electricity, but it will be used as the the centre of distribution and for the administrative work of the department.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

THE NEW SPIRIT IN INDUSTRY.

Sir,—In reference to a new spirit in British industry from a workman's point of view, I suggest that employers of labour get together and call on the Government to assist in lowering tariffs in Europe; also lower the taxes and the stamp duties, so that industry can combine together to compete with other countries and the markets of the world; let our ships go out with a load and return likewise; let us lubricate the wheels of commerce with the latest methods of production and co-operation, change the system of our factories by high production and payment by results. It does certainly appear that the attitude of many of the trade unions is wrong; in fact, a bogey, inasmuch as it aims at restriction of output. Their idea is that the less work done the more will be employed, that is a farce; the proof of the pudding is the eating thereof; low wages, low production. The good mechanic is punished for the bad one; we keep the most incompetent at the same pay as the best mechanic; therefore grousing. We seem to be walking backwards, instead of forward, like our American cousins. It is not only in factories, but at the docks; take the loading and discharging of ships, restrictions of hours of work, picking your own gang. All assist to put up the cost on the goods handled; the quicker the ships turn around, the better for us all. There is also plenty of room for new methods and machinery at the docks. Then there is the amount of time lost while other men cannot get a talley. If we are to remain on the map there must be a radical change and a proper system in all our industrial matters, and the improvement must come quickly. Divide the taxes so that some of that money will be used on new machinery for productions, then we shall be able to lower the dole, less Board of Guardians, less workhouses; more work is wanted, so that everybody will be contented, except the walking delegate. He must growl or otherwise we should lose sight of him. Let us get the spirit of self-reliance and let the delegates go to work for a living instead of dabbling in politics. The dole has substituted a training in how to live without work. Our skilled men are jumping it to other countries, disgusted with the way things are carried on. This shows that men who have the price and are willing to work are driven out of the country. The restrictions of output and the restrictions of new machinery by some of our trade unions is a disgrace to the country and our commerce. Look at the mess we are in to-day with mixing politics with industry. Whoever gains, the delegate gets pay from his union, and if an M.P. another pay. I say to H—— with politics in industry, besides thousands of pounds wasted which should be for protecting its members in case of need. Sack the lot, and let us turn over a new leaf and make a new start; high production with high wages. Give it a trial and you will never look back. I want trade unions, manual workers, employers to pull together so that they may see that to restrict output is cutting their noses off their own faces, and diminishing the livelihood of other workers. Until we get the Yankey spirit of production, we cannot compete with international competition. Take the Yankey locomotive. It is guaranteed for ten years; they expect ours to last a lifetime and compete in the markets at the same time. Let us have a little more quantity and a little less quality. To retain an industry requires constant watchfulness on the part of industrial leaders; there must be no standing still, we must go forward or backwards. I hear that the American Press have the opinion that Old England is done for. Far from it; in fact, if our employers will pool their knowledge and put their shops in order, it would go a long way in giving Uncle Sam a run for his trade. At the present time Great Britain has the ships, the men, rubber, tin, gold, tea, nickel, jute, &c., and still to-day we find ourselves receiving steel from Germany, Belgium, France, and steel castings up to 11 tons in weight from Czecho-Slovakia for our shipyards. Let us put the right men in the right place and pull together. Patriotism is not enough; it must be allied with common sense and understanding of hands and brain; and if we want industrial peace we can get it solely through industrial understanding, and that can be realised solely by an unselfish patriotism which recognises that the home where we bring up our family is the altar of humanity.

J. H. Jones,
Late Foundry Foreman.

Liverpool, November 1st.

LOCOMOTIVE DESIGN.

Sir,—May I be permitted to "damp" the "fired imagination" of Mr. Vernon on locomotive design, which appeared in your issue of October 22nd, 1926, and to tender the following as a justification of modern locomotive practice?

It is not economical to expand steam beyond a definite limit, for the small amount of extra work done beyond this limit of expansion is only obtained at a large relative cost. This is the limiting factor in the number of cylinders. In marine practice large quantities of steam are condensed, and the heat loss is thus minimised. This, however, is not an economic possibility in the locomotive engine.

Our engines to-day are "Rockets in essence," for they certainly have pistons, cylinders, &c.; but their efficiency is a comparative revelation in progress.

Mr. Vernon states that the boiler is mixed up with the engine. This seems incorrect, for although the boiler is over the engine, it is entirely clear of it, and is sufficiently close to it to approximate to an ideal condition, viz., minimum length of supply pipe and hence smaller radiation and condensation losses.

Suppose Mr. Vernon incorporated a different type of boiler into his proposed design and thus separated the boiler from the engine. This would give a more uneven distribution of weight over the wheel base than at present exists and the tractive effort would be impaired.

I have yet to see a "steam motor car" with the boiler and engine well separated, and would like to point out to your correspondent that he has apparently overlooked the fact that in an internal combustion engine the cylinders take the place of the boilers and the cylinders of a steam engine, hence the reference to the sagacity of the modern motor car engineer "leaves me cold."

With reference to the movement of the regulator, presumably Mr. Vernon is not conversant with most modern practice and tendencies, for a survey of regulator control of some modern English and American locomotives would show him that his ideals have already been realised, and a seat has been provided for that "dirty dog of a driver" (*vide* Mr. Vernon), whose necessity for transverse oscillations with a view to signal reading has been eliminated. Personally, I have never experienced any difficulty, however, in operating the usual type of regulator valve control.

Mechanical stoking on coal-fired locomotives is not employed because of (1) a large variation of feed being the rule rather than the exception; (2) difficulty of arrangement of a mechanical feed between two units which have a motion relative to one another, for a "flexible feed" would have to be devised. Has Mr. Vernon any suggestions? (3) If the boiler and the coal bunker were on one wheel base—which is seemingly Mr. Vernon's idea—then mechanical feed would be a possibility; but where would the tractive effort come from, for the weight of the engine itself would be insufficient to prevent slipping of the wheels?

Hammer blow exists in a slight degree because only primary balancing is possible with less than six cylinders.

If Mr. Vernon is sufficiently interested, however, he will find most of his difficulties solved by reference to some standard work on balancing, or to "Steam Power," by Professor W. E. Dalby.

Trusting and hoping that Mr. Vernon has not incurred the "just wrath of his several C.M.E. acquaintances."

Bernard E. Martin, A.C.G.I., B.Sc. (Eng.), Lond.

Carshalton, November 2nd.

THE EIGHT-IMPULSE LOCOMOTIVE.

Sir,—I do not know whether Wilson's four-cylinder engine of 1825 can be regarded as having been an eight-impulse locomotive, but the first relatively modern engine to have eight beats per revolution of the driving wheels was Mr. D. Drummond's 4–2–2–0 express engine, built by the London and South-Western Railway Company at Nine Elms in 1897, and numbered 720. Five similar 4–2–2–0's, Nos. 369–373, were turned out at the same works in 1901. As indicated by the wheel notation, the two pairs of driving wheels were non-coupled. The front pair were driven by the inside cylinders, and the trailing pair by the external cylinders. As there was nothing to prevent either pair of wheels from slipping and so getting "out of step," the exhausts would be liable to be irregular; and as, moreover, the inside and outside cranks had no fixed relationship to one another, there could be no definite balancing of the reciprocating masses as when coupling-rods are employed and the inside and outside cranks on the same side of the engine are at an angle of 180 deg. to each other. Thus, unless the cranks of the 4–2–2–0 engines by chance stood at that angle, there would not be that evenly sustained draught on the fire that occurs with the 135 deg. crank arrangement, which, as side rods maintain the proper relative positions of the cranks, results in eight regular impulses per revolution, and also in an improved torque. The working of Mr. Maunsell's 4–6–0 engine, the Lord Nelson, with this new crank setting, will be watched with the keenest interest.

It is worth recalling that it was on the London and South-Western Railway section of what is now the Southern Railway—on which the Lord Nelson is in service—that the four-cylinder simple 4–6–0 type was first introduced in this country—in 1905.

F. W. Brewer.

Stevenage, Herts., October 30th.

WATER HAMMER.

Sir,—Recent notes on an explosion due to water hammer emphasise the fact that the physical mechanism behind occurrences of this kind is seldom stated clearly. Much is written about a plug of water driving like a piston along a pipe or through a valve, but very little about the condensing steam which is the real villain of the piece. Without the steam the water would be comparatively harmless.

If water be driven along a pipe line previously full of air, serious hammer is not so likely to develop, because directly the water begins to close up against any obstacle, the bubbles of entrapped air act as compressible cushions and reduce the shock. If, on the other hand, high-pressure steam is being admitted into a system in which comparatively cool water is present, any bubbles or pockets of steam condense very rapidly, and especially so if the pressure around them be high. Any water approaching the wall of a valve or pipe with steam in front of it will close up violently against it, impelled by the high-pressure steam behind and the vacuum caused by the condensation of the occluded steam in front. As the water is practically incompressible an absolutely uncushioned blow is delivered, which may be very heavy, even if the bulk of the water had no high velocity beforehand.

This consideration is not in any way incompatible with the plug theory, but so many cases arise in which it is almost impossible to account for the presence of a true plug without making far-fetched assumptions, that some additional explanation certainly seems to be needed.

An illustration of the enormous forces which can be brought into play by the closing up of vacuous bubbles in water is provided by the case of the pitting of propeller blades. The individual shocks in such cases are very small because the bubbles are small, but they are so violent and highly localised that the surface of the metal is in time broken up. In cases of water hammer in a pipe line, the steam-filled cavities may be large and correspondingly greater blows may be produced.

L. H. E. Dibbs.

Teddington, November 1st, 1926.

THE FLETTNER RUDDER.

Sir,—I have read with considerable interest the letter from Mr. Christie which was published in your issue dated 15th inst. The criticism which he makes in regard to the Flettner rudder is, I fear, somewhat unfounded, and certainly calls for comment.

Your correspondent overlooks the fact that the main rudder itself is balanced, so that by giving a certain amount of helm to the secondary rudder, or Flettner fin, the balance of the main rudder is upset, and it swings until it reaches a position depending on the amount of helm given to the secondary rudder.

Due solely to the fact that the Flettner rudder is current operated, it has been found in practice to be considerably more sensitive and positive in its action than any normal type of rudder.

No doubt it may be of interest to know that there are a number of sea-going vessels in service to-day fitted with Flettner rudders, which at a speed of 12 knots can be put from "hard over" to "hard over" in ten seconds; also the vessels to which I refer have a turning circle of under twice their length.

In regard to the remarks on Rhine barges, there are some ninety of these craft already fitted with this type of rudder, and giving satisfactory service.

The power required for moving the Flettner rudder is derived solely from the stream or current created by the propeller, or, in the case of dumb barges, from their forward motion through the water.

F. Arnold Bent.

London, S.W. 1, October 29th.

THE HISTORY OF THE TELEPHONE.

In his introductory address as chairman of the North Western Centre of the Institution of Electrical Engineers on Tuesday, 2nd inst., Mr. W. J. Medlyn, M.I.E.E., Superintending Engineer of the Post Office Telephones in South Lancashire, gave in an interesting form the history of the public telephone service. Starting with the first public service in Boston, U.S.A., in 1877, New York in 1878, and London in 1879, the author traced the numerous developments down to the present time. He said that in the early systems a speaking battery, usually consisting of two primary cells, was directly associated with each telephone, but that a distinct forward step was made in 1900 by the introduction of the common battery system, which provided for the use of a large capacity common battery of secondary cells at the exchange in lieu of a separate battery for each instrument. The first practical machine switching system, or the automatic telephone, giving facilities to subscribers to make their own connections without the intervention of the exchange operator, was invented by Strowger, of Kansas City, in 1889, and ten years later the first automatic switch was brought to this country. In 1896 the telephone trunk lines for long-distance communications were taken over by the Post Office, while in 1902 the Post Office inaugurated its London telephone system, and in January, 1912, the National Telephone Company's undertaking was transferred to the State.

With the growth of the industry the range of speech transmission had been greatly extended, from 45 miles in 1880 to 3600 miles in 1915. Speech transmission difficulties arose where submarine cables became necessary, and for many years communications were limited to the London–Paris service, which was opened in 1891; while in March last regular communication between London and Berlin, *vid* Holland, was made possible.

Some interesting particulars of the London–Manchester underground telephone cable, which was completed and brought into use in April, 1922, were given. It was explained that that cable contained 160 pairs of copper wires, each wire weighing 40 lb. per mile; 104 of the pairs were intended for telephone communication and 56 pairs for telegraphs. By means of "phantom" apparatus, the 104 telephone pairs could be utilised to form 156 long-distance lines. The length of the cable was nearly 200 miles.

Institution of Production Engineers.—The third annual dinner of the Institution of Production Engineers was held at the Engineers' Club, Coventry-street, on Friday, October 29th, with Mr. R. H. Hutchinson in the chair. After the usual loyal toasts, Sir Alfred Herbert proposed "The Institution." He said that, in general, engineering work was mediocre, but once in a while a genius appeared. Inventors were, in fact, born, not made, but they required the assistance of others to develop their ideas by a steady stream of improvement, and it was the function of the production engineer to provide that stream. "The President," was proposed by Mr. H. S. Locker, and "Our Guests" by Mr. J. D. Scaife, while the response to the latter toast was by Mr. C. E. Gordon England. Musical entertainment was provided by Miss Winnill and Mr. Gamlin, and some clever card tricks were performed by Mr. Huggins.

National Coal Products Exhibition.—The National Coal Products, Chemical and Engineering Exhibition, which has been organised by the Manchester Section of the Society of Chemical Industry, will be opened at the City Hall, Deansgate, Manchester, on November 10th. In connection with this Exhibition, a comprehensive exhibit of models, drawings and photographs, illustrative of plant and process in the coal and allied industries, is being arranged. Firms desirous of including such models, photographs and drawings should write immediately to the honorary local secretary of the Society of Chemical Industry, College of Technology, Manchester, stating the nature of the models, &c., which can be lent, and their approximate sizes. Those participating will be required to deliver the models at the City Hall, Manchester, before Friday, November 12th, and must arrange to pack and collect them at the close of the Exhibition on November 27th. The Manchester Section of the Society of Chemical Industry will not accept liability for damage to any exhibit during the course of the Exhibition, but reasonable care will be exercised.

The Cause and Prevention of Embrittlement of Boiler Plate.*

By SAMUEL W. PARR and FREDERICK G. STRAUB.

I.—Introduction.

Inception of Investigation.—Within recent years a phenomenon of more or less frequent occurrence has become recognised, to which the term "the embrittlement of boiler plate" has been applied. Because of the relatively infrequent occurrence of this difficulty and the more or less obscure causes which bring it about, the fact of embrittlement has been largely in question. However, both the evidence of its presence and the conditions which promote it are matters of paramount importance at the present time, because within recent years an increased number of boiler failures chargeable to embrittlement have occurred.

This investigation was undertaken by the Engineering Experiment Station of the University of Illinois in continuance of former studies, for the purpose of developing information of general interest to all, whether concerned with the production of power or the fabrication of boilers.

In the early stages of experience along this line, connection seems to have been made with failures of fabricated metal used in processes where caustic solutions were involved, as in the manufacture or use of sodium hydroxide, and under these conditions the term "caustic embrittlement" was employed. It was soon evident that a certain relation existed between embrittlement resulting from the use of actual caustic solutions and embrittlement apparently occurring in boilers with certain waters, by reason of the fact that in the case of such occurrences the water used in the boilers was also shown to be caustic. Hence the term "caustic embrittlement," which is often applied to this phenomenon, might seem to be justified, but in the present discussion only the general term "embrittlement" is employed.

The use of the term "embrittlement" is here continued for the reason that it has become fairly well fixed in the literature. This is a natural result of the earlier attempts to connect the cracking of boiler plate with hydrogen embrittlement. As a matter of fact, the two phenomena are widely different, though the liberation of atomic hydrogen may be a contributing cause in promoting chemical changes in the bonding material between crystals. Until a more complete understanding is reached as to the mechanism involved it is deemed wiser to continue the use of the term embrittlement in this discussion.

Outline of Investigation.—It was determined at the outset that it was desirable to make a critical survey of the situation with a view to establishing beyond any question the facts *pro* or *con* as to the actual existence of such a thing as embrittlement. In order to study the matter of embrittlement, therefore, it was deemed essential in the first place to develop some means of recognising cases of embrittlement which would be reliable without question, and distinctly to differentiate such phenomena from other similar or related conditions. This led directly to a study of the cracking of rolled or fabricated plate. The studies along this line have revealed the fact that three types of cracks may occur, as follows :—

(*a*) Corrosion cracks,
(*b*) Fatigue cracks,
(*c*) Embrittlement cracks.

Each one of these three types is distinctive and can be definitely differentiated from the others by micrographic analysis. These characteristics may be briefly described as follows :—

(*a*) Corrosion cracks, as the name implies, are due to direct corrosion of the metal. This follows in principle the well-known phenomenon where parts of a metal differ in composition or physical properties from other parts, due to strains, or density, or impurities. In the presence of an electrolyte, by reason of the fact that one portion of the metal is electropositive to another, a galvanic circuit is set up, there is started a solution action on the positive side, and a corrosion area is thereby developed. These corrosion areas or cracks in the case of metal under stress will follow the lines of stress as would naturally be expected. Also, since the solvent action is accentuated, or occurs in the presence of that type of ionisation wherein the hydrogen ions predominate, one would expect to find such examples of corrosion in the presence of electrolytes, as nitrates, chlorides, or sulphates. Such corrosion phenomena would be checked or inhibited by the presence of hydroxyl ions or that condition where an alkaline state exists. This in itself will explain why one would not expect to find corrosion cracks in boilers using waters which are alkaline in character. A study of chemical corrosion does not necessarily require a micrographic analysis of the structure of the corroded surface, but the specific feature should be noted, that the direction of the cracks follows the lines of stress without regard to grain areas; that is, the cracks proceed across the grains and disregard the grain boundaries in their path of development.

(*b*) The development of cracks due to stress alone furnishes interesting illustrative material in the study of metal cracks. It seems that in metals placed under reverse stress, as failure is approached, cracks develop, which upon micrographic study reveal a positive characteristic serving as a ready means of identification. By examination of a few type specimens it is obvious that the cracks which have been started as a result of fatigue do not respect the fact of grain structure in the metal, but follow a course quite independent of grain boundaries, and are hence described as cross-granular as opposed to inter-granular in their directional development.

(*c*) It is now possible to differentiate those cracks which accompany embrittlement from either of the types already described for the reason that a micrographic study shows one distinctive characteristic of this type of crack. By reference to the micrographs of embrittlement cracks, especially when the surface is etched in such a manner as to bring out clearly the grain boundaries, it is very evident that, almost without exception, these embrittlement cracks follow grain boundaries.

With this very definite method of identifying any cracks which may occur in connection with boiler plate, it has been possible to make an extended survey of the situation geographically, as well as from the standpoint of boiler fabrication and of boiler water treatment.

* University of Illinois, Bulletin No. 155. Abridged.

II.—Occurrence of Embrittlement.

Cases of Embrittlement.—In general the cases of embrittlement may be discussed under four headings: (*a*) Regional areas where a specific type of natural water exists; (*b*) waters causing embrittlement as the result of the direct application of chemicals; (*c*) type of boiler; and (*d*) quality of boiler plate.

(*a*) It is clearly evident that certain regional areas may be defined in which embrittlement is more evident than in others. The waters of those regions are characterised by an almost complete absence of sulphates, but this is accompanied by another very marked characteristic, and the one which is primarily responsible for the embrittling action, namely, the presence of free sodium bicarbonate.

Table I.—*Chemical Analyses of Plates from Embrittled Boilers.*

Location boiler.	Content per cent.			
	C.	Mn.	P.	S.
Bloomington, Illinois	0·17	0·26	0·015	0·046
Hartland, Illinois	0·22	0·39	0·017	0·024
Champaign, Illinois	0·20	0·50	0·005	0·024
Los Angeles, California	0·22	0·54	0·013	0·036
Houston, Texas	0·26	0·34	0·014	0·025
Railway	0·14	0·37	0·018	0·018

It will thus be seen that these waters have only temporary hardness due to the presence of bicarbonates of lime, magnesium, and iron, and that there is a substantial absence of sulphates of these elements. Waters from isolated wells capable of causing embrittlement may be met with in almost any region because of the modern tendency toward deeper wells.

(*b*) As will be seen later, the cases of embrittlement which can be traced to water treatment are comparatively few in number, but the possibilities of such distress, if even remotely present, should be thoroughly understood and the knowledge of how to avoid the difficulty should be quite as eagerly sought by water-treating establishments as by the users of such water-treating formulas or apparatus.

(*c*) The type of boiler seems to be without effect so far as tendency toward embrittlement is concerned, and any idea that one type of boiler is more subject to this trouble than another appears to be wholly without foundation. That is to say, instances of embrittlement have been found in boilers of different makes and designs in sufficient number to warrant the statement that the embrittling effect is not confined to any particular make or type of boiler, all of the standard makes of both fire and water-tube boilers being represented in the investigation.

(*d*) Not a little controversy has also centred in the question as to whether the embrittling effect may not be due to faulty composition of the iron. This question seems to have been decided by this investigation, to the effect that embrittling action occurs without regard to the impurities or composition of the plate and that any idea that embrittling distress may be due to faulty iron is without basis in fact. By this is meant that embrittlement is not confined to faulty or dirty iron, but occurs quite as consistently in iron of the best grade as in lower grade iron.

Table III.—*Analyses in Grains per U.S. Gallon of Zeolite Treated Waters Used in Embrittled Boilers.*

	Buffalo, New York.		Auburn, Indiana.		Lawton, Oklahoma.	
	Lake water.	Tr't'd	Well water.	Tr't'd	Lake water.	Tr't'd
Calcium carbonate	5·28	—	10·85	5·10	6·35	1·10
Magnesium carbonate	0·22	—	5·02	0·65	1·11	0·29
Sodium carbonate	—	5·83	1·38	15·30	—	8·90
Sodium chloride	1·11	1·25	1·54	7·65	1·05	1·45
Magnesium sulphate	1·30	—	—	—	0·55	—
Sodium sulphate	0·20	1·63	0·74	0·43	0·88	1·51
Iron oxide and alumina	Trace	Trace	—	—	Trace	Trace
Silica	0·12	0·14	—	—	0·11	0·42
Total solids	8·46	8·85	19·50	29·20	10·05	12·67

Summary of Embrittlement Characteristics.—The salient features which are characteristic of embrittlement may be more fully understood after a brief survey of a few typical examples taken from numerous cases which have come to the attention of the investigators.

Fig. 1, for example, shows a blow-off flange and it may be inferred, from the frequency with which cases of this sort are met with that the difficulty may be accentuated by the vibratory effect produced by the blowing-off process.

Fig. 2 shows the inside of a drum from which twenty six rivet heads were knocked off by sharp blows from a hammer. Fig. 3 shows a drum head from a 770 horse-power boiler. The characteristics of cracks in such cases may be summarised as follows :—

(*a*) The cracks do not follow what is generally considered the line of maximum stress.

(*b*) They start on what is termed the dry side of the plate.

(*c*) They run, in general, from one rivet hole to another,

FIG. 1—BLOW-OFF FLANGE

though they often run past each other, leaving islands of plate.

(*d*) They are irregular in direction.

(*e*) They never extend into the body of the plate beyond the lap of the seam.

(*f*) There is no elongation of the plate.

(*g*) Where extreme action has occurred rivet heads crack off or are easily dislodged by a slight blow of the hammer.

A summary of conditions relating to the location of cracks in the boiler may be given as follows :—

(*a*) The cracks always occur below the practical water level.

(*b*) They occur in seams under tension.

FIG. 2—INSIDE OF STEAM DRUM

(*c*) They are found at places where the highest localised stresses might be assumed to occur.

(*d*) The cracks occur in plates having practically perfect chemical composition and physical properties, as well as in plates of inferior make.

Table I. gives the chemical analyses of boiler plate in which a few typical cases of embrittlement have occurred.

FIG. 3—PART OF STEAM DRUM HEAD

Summary of Water Conditions.—A summary of the chemical conditions which characterise the water used in the boilers where embrittlement has occurred is as follows :

(*a*) Sodium carbonate is the one substance which is always present in the feed water.

(*b*) Sulphate hardness is usually absent or of a low ratio with respect to the sodium carbonate present. Sodium sulphate is similarly lower in amount than the sodium carbonate.

(*c*) Boilers encountering this trouble use waters having

Table II.—*Analyses in Grains per U.S. Gallon of Well Waters Used in Embrittled Boilers.*

	Bloomington, Ill.	Urbana & Champaign, Ill.	De Kalb, Ill.	McHenry County, Ill.	Watseka, Ill.	Paxton, Ill.	Sycamore, Ill.	Los Angeles, Cal.	Dallas, Texas.	Denver, Colo.	Houston, Texas.
Calcium carbonate	9·27	9·75	8·23	6·27	5·55	9·97	9·22	3·55	1·47	0·60	2·58
Magnesium carbonate	6·82	6·34	4·72	5·18	2·99	6·64	6·26	0·38	1·01	0·26	0·00
Sodium carbonate	3·21	4·52	3·93	3·12	8·82	3·96	1·99	7·71	21·70	5·96	7·1
Sodium sulphate	0·00	0·10	0·08	0·00	0·83	2·36	0·16	5·72	11·92	1·49	0·0
Sodium chloride	3·85	0·47	0·10	0·39	0·54	0·25	0·24	5·10	4·21	0·70	12·1
Iron oxide and alumina	0·12	0·10	0·07	0·53	0·09	0·03	0·17	—	—	0·05	0·0
Silica	0·58	0·82	0·40	0·23	0·31	1·82	1·18	0·95	2·51	0·63	—
Total solids	26·35	23·17	17·92	16·03	20·14	27·80	19·45	—	48·30	9·69	—

the characteristics noted under (*a*) and (*b*), and as a consequence of chemical reaction within the boiler, develop a caustic condition with the sodium hydroxide in material excess over the sodium sulphate.

Table II. gives the analyses of well waters which have been used in embrittled boilers, while in Table III. the composition of zeolite treated waters which have embrittled boilers is given. A comparison with Table IV., which gives the analyses of waters which do not produce embrittlement, serves to substantiate this summary.

III.—Laboratory Reproduction of Embrittlement.

Criterion of Reproduction.—It will be evident at once that if a method could be devised for reproducing the feature of embrittlement at will, a ready means would be available for determining both the cause of and the remedy for the difficulty.

Intercrystalline cracking of mild steel is an abnormal type of failure; consequently, if mild steel can be made to crack under conditions which may be controlled or modified at will, and under conditions which parallel those of actual boiler operations, both the cause and the remedy may be in a fair way of discovery.

Testing Apparatus.—The apparatus finally used for the reproduction of embrittlement is shown in Fig. 4. It consists of a welded steel container A, which holds the solution, and B, a tension producing equipment. The tension is produced and maintained by means of the spring C and the plunger D. The gland E allows the plunger to enter the container steam-tight. The specimen is shown at F. Part B fits into A and is secured by bolts (not shown). The proper temperature and pressure is maintained by means of an electric furnace.

Materials Embrittled.—The materials used for the embrittling tests were all mild steels. Table V. gives the chemical analyses and reference numbers of the different metals tested; Table VI. gives the physical properties.

Test Specimens.—The materials to be tested were cut to the shape shown in Fig. 5. Care was taken in machining the specimens to have the holes aligned so as to distribute the stress properly. The specimens were finished by polishing the small section with No. 1 polishing emery paper. The direction of the polish was made parallel to the length of the specimen.

Procedure in Tests.—The specimen to be tested was measured with a micrometer and the area calculated. The load necessary to give the required stress was calculated and the compression of the standardised spring to give this load determined. The specimen was set in the yoke and pinned to the plunger which was tightened by screwing down the nut on the upper end. When the spring had been compressed to the right length the gland was tightened and the upper part placed on the container in which the desired solution had previously been placed. After the parts had been tightly bolted together they were placed in an electric furnace and heated until the desired pressure was obtained. A record of the pressure, temperature, and spring length was taken at regular intervals. When embrittlement had progressed sufficiently to break the specimen the spring forced the plunger up, thus indicating that the specimen had broken. The release of the spring was in all cases found to be instantaneous and free from any indications of slow yielding.

The average area of the test specimens was 0·05 square inch. The accuracy of the estimated load on the specimen was within 1000 lb. per square inch when the stress was in the range of 40,000 lb. per square inch. In calculating the stress allowance was made for the stress added by the steam pressure acting on the plunger.

Table IV.—*Analyses in Grains per U.S. Gallon of Surface Water in Districts in which No Cases of Embrittlement are Known.**

	Reservoir, Carter, Ill.	Fox River, Elgin, Ill.	Rock River, Rockford, Ill.	Embarass River, Lawrenceville, Ill.	Mississippi River, Chester, Ill.	Mississippi River, Quincy, Ill.	Mississippi River, Moline, Ill.	Illinois River, Kampeville, Ill.	Illinois River, Peoria, Ill.	Illinois River, La Salle, Ill.	Big Vermilion River, Danville, Ill.	Big Muddy River, Murphysboro, Ill.	Sangamon River, Decatur, Ill.
Calcium carbonate	0·98	6·09	6·09	4·94	4·85	4·73	4·30	5·35	5·56	5·20	6·52	1·34	7·28
Magnesium carbonate	0·71	6·03	5·01	4·05	3·21	3·21	2·61	4·02	4·21	4·42	5·03	2·42	5·23
Sodium carbonate	—	—	—	—	—	—	—	—	—	—	—	—	—
Sodium chloride	0·50	0·49	0·44	3·26	0·49	0·42	0·35	1·44	1·25	1·25	0·43	1·47	0·52
Calcium sulphate	0·43	1·80	0·60	1·07	2·09	0·67	0·67	2·02	2·13	2·82	1·73	3·98	1·09
Sodium sulphate	0·92	1·37	1·25	0·95	2·61	1·44	1·36	1·48	1·89	1·36	1·80	2·06	1·88
Iron oxide and alumina	0·15	0·02	0·08	0·04	0·03	0·04	0·03	0·02	0·02	0·02	0·02	0·17	0·02
Silica	0·93	0·69	0·87	0·99	1·28	1·04	0·93	0·69	0·69	0·69	0·82	1·40	1·11
Total solids	4·62	16·49	14·34	16·30	15·02	11·55	10·25	15·02	15·75	15·75	16·35	14·62	17·33

* Analyses from R. B. Dole, "Surface Waters of the United States."

Table V.—*Chemical Analyses of Metals Tested.*

Reference.	Description.	Content, per cent. C.	Mn.	P.	S.	Si.	Ni.	Mo.
F.S.	Flange steel	0·18	0·45	0·012	0·027	—	—	—
Armco	Armco iron	0·023	0·017	0·003	0·010	0·01	—	—
M.I.	Magnetic iron	0·04	0·020	0·004	0·007	0·01	—	—
C.R.	Cold rolled	0·30	0·42	0·015	0·044	0·04	—	—
1112	S.A.E. 1112	0·15	0·76	0·215	0·126	0·01	—	—
2312	S.A.E. 2312*†	0·115	0·45	0·018	0·025	0·20	3·5	—
2212	Special*†	0·13	0·45	0·018	0·020	0·26	1·57	0·25
2330	S.A.E. 2330	0·30	0·478	0·023	0·015	0·05	3·42	—

* Furnished by Central Steel Company, Massillon, Ohio. † Cut to ¼in. flat from 1¼in. round.

Table VI.—*Tension Tests of Materials Used.*

Reference.	Description.	Heat treatment.	Proportional elastic limit.	Yield point.	Ultimate tensile strength.	Reduction of area, per cent.
			Lb. per sq. in.			
F.S.	Flange steel	As received	32,600	35,200	60,400	61
Armco	Armco iron	Annealed 950 deg. Cent.	32,000	40,600	52,600	70
M.I.	Magnetic iron	Annealed 950 deg. Cent.	25,000	30,000	50,700	72
C.R.	Cold rolled	As received	70,000	84,000	85,500	55
C.R.A.	Cold rolled	Annealed 850 deg. Cent.	—	36,400	64,700	55
1112	S.A.E. 1112	Annealed 900 deg. Cent.	47,500	49,000	74,000	56
2312	S.A.E. 2312	Annealed 900 deg. Cent.	37,000	40,000	74,800	75
2212	Special	Annealed 900 deg. Cent.	35,000	36,800	75,000	75
2330	S.A.E. 2330	Annealed 850 deg. Cent.	41,000	49,200	77,300	57

Annealed specimens heated to temperature indicated for 30 minutes and furnace cooled.

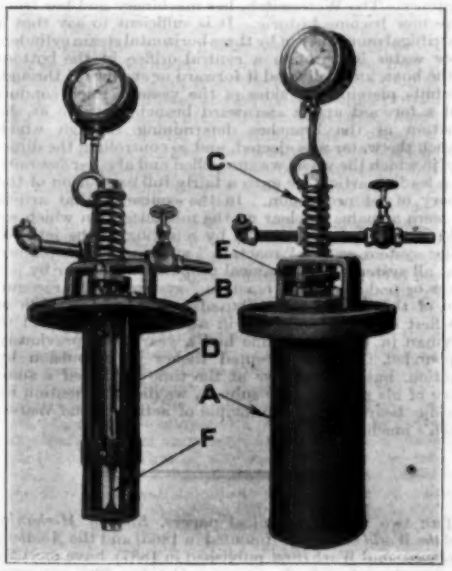

FIG. 4—TESTING APPARATUS

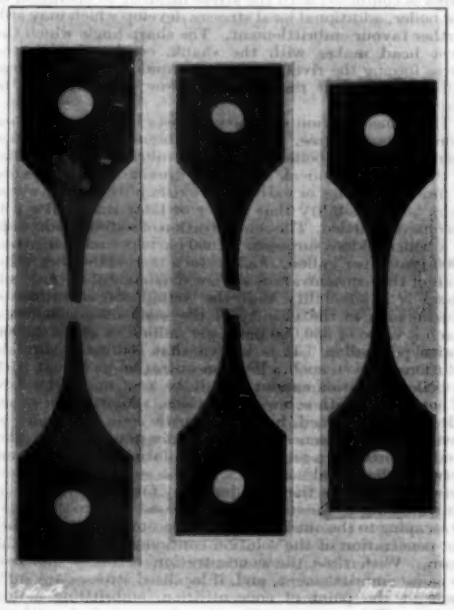

FIG. 5—TEST PIECES

IV.—Test Data on Embrittling.

Data from Tests.—The results of the tests on the various metals embrittled are given in Tables VII. to XI. inclusive.

Table VII.—*Effect of Stress and Concentration of Solution on Flange Steel.*

Solution grammes per litre NaOH.	Stress, lb. per sq. in.	Container No.	Time. Break.	Time. No break days.	Gauge pressure, lb. per sq. in.
415	30,000	1	—	22	65
400	31,600	4	—	18	65
400	33,000	4	—	16	70
415	34,400	1	—	27	90
400	35,400	1	1½ days	—	60
400	39,200	4	2 days	—	55
400	44,300	4	30 hrs.	—	50
400	46,000	2	1½ days	—	45
400	50,500	4	27 hrs.	—	50
40	50,000	1	—	17	55
200	47,000	3	—	16	40
210	47,600	3	—	21	65
345	46,000	4	14½ days	—	65
405	50,000	4	4½ days	—	50
400	39,200	4	2 days	—	55
455	52,000	3	2½ days	—	95
575	46,700	3	8½ days	—	50

These results indicate that two conditions must be present simultaneously to cause embrittlement of mild steel: first, the actual stress must be above the region of the yield point of the metal; and secondly, the concentration of sodium hydroxide must be in excess of 350 grammes per litre (350,000 parts per million, about 20,000 grains per gallon).

The variation of pressure up to 200 lb. per square inch seems to have no marked effect on the rate of embrittlement.

Table VIII.—*Effect of Solutions of Salts other than Sodium Hydroxide on Flange Steel.*

Salt used.	Concentration, grammes per litre.	Stress, lb. per sq. in.	Container No.	Time, no break dyas.	Gauge pressure, lb. per sq. in.
None	Distilled water	48,600	1	28	50
Na_2CO_3	500	50,000	3	34	70
Na_2SO_4	500	45,000	4	30	70

Distilled water, sodium carbonate solution, or sodium sulphate solution used in place of sodium hydroxide did not affect the metal even when the stress was up to the point of failure when sodium hydroxide was used.

Table IX.—*Effect of Cold Work.*

Specimen tested.	Stress before testing.	Stress during test.	Container No.	Time. Break.	Time. No break days.	Gauge pressure, lb. per sq. in.
F.S.	—	39,200	4	2 days	—	50
F.S.	55,000	25,000	2	—	22*	50
F.S.	Cold worked 20% elongation	25,000	1	—	27	55
F.S.	Previous specimen continued	45,000	1	12 hrs.	—	90
C.R.	—	25,000	2	—	24	85
C.R.	—	38,000	2	—	24	85
C.R.	—	45,000	2	17½ days	—	80
C.R.	—	55,000	2	26 hrs.	—	85
C.R.A.	—	38,000	2	36 hrs.	—	85

* Tested for tensile strength after 22 days in solution. Ultimate tensile strength 69,200. Reduction in area 52 per cent.

Table X.—*Effect of Chemical Composition.*

Specimen tested.	Solution, gr. per litre NaOH.	Stress, lb. per sq. in.	Container No.	Time. Break.	Time. No break days.	Gauge pressure, lb. per sq. in.	Yield point, lb. per sq. in.
Armco	409	40,200	2	—	14	75	40,600
Armco	400	45,000	2	21 hrs.	—	70	40,600
M.I.	405	35,000	2	23 hrs.	—	50	30,000
F.S.	418	50,000	2	20 hrs.	—	60	35,200
1112	409	55,000	2	3½ hrs.	—	50	49,000
1112	400	40,000	2	15 hrs.	—	80	49,000
1112	427	35,000	4	—	20	80	49,000
1112	427	25,000	4	—	25	85	49,000
2312	375	48,000	2	29 hrs.	—	80	40,000
2312	450	43,000	4	8½ days	—	85	40,000
2212	385	45,000	2	20 hrs	—	65	36,800
2330	375	55,000	4	3½ days	—	65	49,200

The temperature of the previous complete annealing had

no marked effect on the rate of embrittlement, neither had the stress, once the yield point was passed.

If the metal has been cold worked to an excessive degree previous to testing for the rate of embrittlement the stress necessary to start this effect will not be lowered, but from the evidence at hand it appears that a higher stress will be required than for the original unworked metal.

Variation of chemical composition of the metal within the limits set for flange steel has very little effect on the rate of embrittlement. Thus steels of the following general composition show no noticeable variation in behaviour with respect to embrittling action :—

	Per cent.
Mn	0·017 to 0·45
S	0·007 to 0·027
P	0·003 to 0·012
C	0·023 to 0·30

The introduction of 3·5 per cent. nickel with the carbon either 0·115 or 0·3 per cent. has no effect other than raising the yield point and, consequently, the initial stress necessary to start embrittlement.

When the sulphur becomes 0·215 per cent. and the phosphorus 0·126 per cent. the rate has a marked acceleration.

The embrittled specimens are not corroded, but are covered with a thin shiny blue-black coherent coat of

TABLE XI.—*Effect of Previous Heat Treatment, Chemical Action and Pressure on Flange Steel.*

Solution, gr. per litre NaOH	Stress, lb. per sq. in.	Con-t'n'r. No.	Time. Break.	Time. No break days.	Gauge pressure, lb. per sq. in.	Treatment.
400 ..	39,200	4	2 days	—	55	No treatment
400 ..	50,000	2	2 days	—	55	Annealed 1050° C.
418 ..	50,000	2	20 hrs.	—	55	No treatment
407 ..	50,000	2	20 hrs.	—	45	Dil. HCl 20 minutes
407 ..	50,000	2	17 hrs.	—	55	Lower half $PtCl_2$ solution
400 ..	50,000	2	36 hrs.	—	55	All $PtCl_2$ solution
404 ..	50,000	4	—	16	0*	
400 ..	46,000	2	1¼ days	—	45	
390 ..	50,000	2	2 days	—	200	

* Open to air.

magnetic oxide of iron. They show no marked elongation or reduction of area at the break. Fig. 5 shows the fracture of an embrittled specimen as compared with that of a regular unembrittled specimen.

Micro-examination of Embrittled Metals.— Samples of cracked steel were obtained from different instances of this type of boiler distress. When these were examined under the microscope the cracks were shown to be intercrystalline. The manner in which mild steel fails under ordinary stress, either static or fatigue, is almost invariably transcrystalline. The fact that embrittlement cracks progress between the grains indicates that this is not a normal fracture. Furthermore, the crack progresses without any marked deformation of the grain, another deviation from the general behaviour of mild steel static failures.

The specimens embrittled in the laboratory have been examined and found to have a large number of cracks progressing into the strained portion of the metal and all of these are intercrystalline without any marked deformation of the grain. When examined under higher magnification the crack is observed to pass between the smaller grains of pearlite which make up the carbon areas.

V.—Inhibition of Embrittlement.

Laboratory Results.—Since embrittlement is the result of the combined action of chemicals and stress on the metal, it appears possible to stop it by at least one of two methods. One of these would be reducing the stress to a point where embrittlement will not occur. This might be possible if the actual concentrated stresses, such as at rivet heads, around rivet holes, &c., could be calculated, and the boiler constructed so as to keep these stresses low enough. Even this would not ensure an absolute prevention, since some unknown localised stresses might still exist and give rise to the embrittlement condition.

The other method, namely, the removal of the cause of the chemical action, in the absence of which embrittlement would not occur, would be the best procedure ; but even this is prevented in some cases by the fact that a change of water is not always possible. A close approach could be made to this condition by neutralising the alkalinity with some chemical, but complete neutralisation would be impossible without endangering the boiler.

When it is noticed that embrittlement never has occurred even in carbonate waters when the sulphate content is high, the question is raised as to whether or not the existence of a definite ratio between the sodium sulphate and the sodium hydroxide is sufficient in itself to prevent this cracking.

On comparing sodium sulphate with sodium carbonate as to solubility in sodium hydroxide it is found that these two salts are very similar in this respect. This fact, coupled with the knowledge that sodium carbonate in solution will not produce embrittlement appears to indicate that the undecomposed carbonate in a boiler might also act as an inhibitant.

VI.—Discussion of Results.

Mechanism of Embrittlement.—The results which have been obtained justify the opinion which has prevailed in the United States that mild steel is embrittled by sodium hydroxide. They go further in that they show that sodium hydroxide is the only salt in the boiler which will embrittle steel. Stress and chemical attack now appear to be the predominating factors, neither of which can produce embrittlement in the absence of the other.

The action of sodium hydroxide is to produce a thin, compact, and coherent coating of magnetic oxide of iron. Indicating the reaction with the hydroxyl ion only, it is $3\ Fe + 4\ OH = Fe_3O_4 + 4\ H$. If the concentration is kept in the range of 400 grammes to the litre the action progresses slowly without any noticeable evolution of hydrogen. This coating makes the iron passive or resistant to further action of the hydroxide. If this coat is cut, removed, or penetrated, the fresh metal beneath is as active as the original surface. In a solution of ten normal NaOH (400 grammes per litre) the E.M.F. between the fresh metal and the coated metal reaches 0·7 volt in the cold. This potential is sufficient to produce a slow electro-chemical action which would favour penetration toward the fresh metal.

As long as the metal is subjected to a stress below the yield point the chemical action progresses no further than the production of the outer coat of protective oxide. When the stress becomes greater than the yield point of the metal the outer coat appears to be broken in the strained areas and the chemical attack progresses into the metal to embrittle it. This statement refers to short-time laboratory tests.

Once the penetration has started the chemical action follows the more chemically active path which is between the grain boundaries. As the boundaries are attacked the stresses are necessarily concentrated and this favours still more intercrystalline penetration. Observation of the progression of cracks in embrittled steel shows that the cracks do not always start at grain boundaries. Often a crack starts by penetration through the outer grain, but once it reaches a grain boundary it progresses along the boundaries.

In a metal which has been cold worked to a considerable degree the grains are completely changed, slips occur along various planes, the grains are elongated, the original crystal boundaries are almost entirely replaced, and the maximum stress is on the slip planes of the crystals. A higher stress would apparently be necessary here before the chemical action would progress. It would also appear probable that a small amount of cold work would have very little effect on the subsequent embrittling of the metal.

In the pearlitic areas of steel we would expect to find obstacles to the slip of the crystals, and as the carbon content increases the yield point should increase. The paths of embrittlement cracks should be such as to avoid passing across the lines of pearlite, and this is found to be almost invariably so.

Cause of Embrittlement in Steam Boilers.—It has already been shown that the production of intercrystalline cracks in mild steel can be brought about only by the combined action of stress and proper chemical attack. The limits set for each of these factors apply only to the conditions of the laboratory tests and the time occupied in these tests. There is a possibility of a slower action taking place over a period longer than that covered by the tests, which may lower to some degree the stress, or the concentration of solution necessary. Another point to be considered is that the embrittlement tests were run with the metal surrounded by a solution ; in boilers the solution is penetrating between the plates in a thin film and the limits of concentration of solution necessary to produce embrittlement may be altogether different.

When one considers that embrittlement has been observed in the riveted areas which are under tension, it is possible to conceive that in such locations the stress may pass the yield point and the solution reach the high concentrations used in the tests.

Probably in all boiler plates the stresses at the edge of rivet holes occasionally reach the yield point of the metal. It should be remembered that the mathematical theory of elasticity indicates that the localised stresses at the edge of a hole in a plate may be nearly three times the average stress in the plate. This stress concentration at the edge of holes, such as rivet holes, would in itself be sufficient to account for stresses almost high enough to start embrittlement should a solution of proper concentration penetrate to the rivet holes. In addition it should be noted that during the fabrication of the boiler the seams are put together by riveting. The riveting is done hot and, granting that only sufficient riveting pressure is used to maintain tight seams, very high additional localised stress occurs under the rivet heads and around the rivet holes. When one observes the appearance of the plates and straps after they have been removed from a boiler which has been in service and notes the rings around the holes where the straps and plates have been held together by the rivets, there remains little doubt that the metal has locally, at least, been stressed beyond the yield point. When this stress is combined with the stress incident to operation of the boiler, additional local stresses develop which may still further favour embrittlement. The sharp angle which the rivet head makes with the shank, combined with the stress forcing the rivet heads apart, undoubtedly produces sufficient stress at this point to allow embrittlement to start.

This concentration of stresses exists in all boilers to a more or less degree, yet in the absence of the proper chemical in the boiler water no embrittlement results. If the proper chemical, sodium hydroxide, in the absence of much sulphates or carbonates exists in the boiler water there is a possibility that sooner or later that boiler will become embrittled. The concentration of sodium hydroxide in a boiler seldom surpasses 17,000 parts per million, about 1000 grains per gallon. Laboratory tests show that solutions of this concentration are not detrimental to the steel. There is a possibility that the actual concentration of caustic soda in the vicinity of the seam does sometimes reach a value of 350,000 parts per million or about 20,000 grains per gallon. It is known that sodium hydroxide solutions of even such a low concentration as is met with in boiler operation cannot readily be kept under pressure in containers with screw connections. Solutions of other salts can be retained, but with caustic soda leaks tend to develop. The presence of caustic under pressure in a boiler tends to produce a seepage of the solution into the seams between the metal surfaces. As the solution penetrates between the plates there is a tendency for it to become concentrated due to the steam being released back to the boiler or escaping to the outside. As the concentration progresses the penetration of the solution continues further into the seam. With time the concentration becomes sufficient to cause embrittlement, and, if localised stresses are sufficient at the point of concentration, embrittling action begins. This concentration is often reached without embrittlement occurring, apparently owing to the lack of sufficient stresses. In such cases the penetration progresses until a free leak develops, but on examination no presence of embrittlement can be found. In other cases embrittlement occurs, the plates are weakened, and a leak develops, which indicates trouble. When the plates are removed from the seams of embrittled boilers soluble salts are found between the plates. This alone would indicate that there must have been considerable concentration in the seams. Evidence of chemical attack in the seams is given by the presence of finely divided black magnetic oxide deposited on the surface of the plates.

The real causes of embrittlement in steam boilers can be summarised, therefore, as concentration of caustic soda in the seams in the absence of much sulphate or carbonate, together with the existence of localised stresses in the seams.

Prevention of Embrittlement.—The results of the experimental work on the prevention or inhibition of embrittlement indicates that it can be stopped, but at present these experiments are not complete enough to cite final ratios and concentrations of the chemicals involved. The data collected from plant operation point out that the maintaining of certain ratios of these chemicals will prevent this trouble.

The removal of stresses during fabrication is not to be considered in a commercial installation, and if it were possible it could not readily be applied to the many plants already in operation. The practice of inside caulking in drums will, if it can entirely prevent seepage into the seams, tend to retard the occurrence of this type of distress.

The removal of the source of the sodium hydroxide by changing the supply water would be the most effective means of any, but in some instances this is not possible and in others would lead to the use of waters which produce other boiler complications.

One point of particular interest is the fact that undecomposed sodium carbonate acts as an inhibitant. Thus, if a plant should operate with a large percentage of make-up high in carbonates, the amount of hydroxide formed might be lower since the introduction of fresh carbonates would tend to keep the carbonate hydroxide ratio high and might in turn inhibit embrittlement. Cases have been cited in which the sodium sulphate to sodium carbonate ratio has been exceedingly low without any indications of embrittlement, and the neutral effect of sodium carbonate is the obvious explanation.

SIXTY YEARS AGO.

Although the screw propeller as we now know it had reached a fairly high degree of development and application sixty years ago, alternative means of propelling steamships were still being actively sought by many inventors. The screw was for many purposes definitely accepted as superior to the paddle wheel, which it was rapidly replacing, but few regarded it as being incapable of substitution by some better mode of propulsion. In our issue of November 2nd, 1866, particulars were published of two alternative means of ship propulsion. Mr. Jonathan Jopling, a Sunderland ironfounder, was responsible for one. His invention consisted of replacing the ordinary screw propeller by a species of centrifugal pump, mounted to rotate in a horizontal plane and with half its circumference shrouded in a casing. The casing could be moved round the periphery of the pump disc, and according to its position the vessel would be propelled forward or backward or caused to turn. The advantages claimed for the invention were that it combined the propelling and steering means in one unit, and that the vertical space occupied by the propelling device was so small that it could be applied to vessels of the shallowest draught, even to a flat-bottomed boat, drawing no more than 6in. Mr. Jopling had demonstrated, successfully it was stated, the application of his invention by constructing a ferry boat, the Crusoe, drawing 24in. of water, for navigation on the river Wear. It was suggested that the best form of the wheel had not yet been attained, and that after development the invention might be extended to sea-going vessels. The second invention which we described and illustrated in the issue referred to was Ruthven's system of jet propulsion as applied on the ironclad gunboat Waterwitch, built by J. and W. Dudgeon, of Millwall. The drawings of the propelling machinery which we gave were, we claimed, correct in every particular, and were the first to be published which possessed the slightest claims to accuracy. The Waterwitch, her machinery and her trials have now become historic. It is sufficient to say that a centrifugal pump driven by three horizontal steam cylinders drew water in through a central orifice in the bottom of the boat, and delivered it forward or sternward through conduits piercing the sides of the vessel. Each conduit had a forward and a sternward branch, a valve at the junction of the branches determining through which branch the water was ejected, and so controlling the direction in which the vessel was propelled and also her steerage. In a leading article we gave a fairly full exposition of the theory of jet propulsion. In the course of that article we were at pains to clear up the misconception which we held was likely to be caused by referring to the jet propeller system as the "reaction" system. We explained that all systems of mechanical propulsion, whether by jet, screw or paddle, were "reaction" systems. The recognition of that fact was attributed to Tredgold in 1828 in the first instance, and later in a more precise respect to Boyman in 1858. Rankine had a year or so previously expounded the now accepted theory of propulsion by reaction, but although we at the time published a summary of his paper on the subject, we did not mention its obvious bearing on the principle of action of the Waterwitch's machinery.

The two weekly technical papers, *English Mechanics and the World of Science* (founded in 1865) and the *Amateur Mechanic and Work* (first published in 1887), have recently combined, and with the issue for October 29th appeared as a single but enlarged publication at the old price, namely, 3d. These papers have to some extent run on parallel lines in the past in catering for the craftsman, amateur mechanic and woodworker, and also those with scientific and other hobbies, including astronomy and microscopy, and the merging of the two appears to be a natural and wise step. The new publication bears the title *English and Amateur Mechanics*.

Railway Matters.

The municipality of Sao Paulo, Brazil, has approved a contract for a new railway station with six platforms, 206 m. long, three for passenger and three for goods services. The building will be 343 m. long, 57 m. wide and 50 m. high.

In this column of our issue of April 30th last it was mentioned that the electrification of the Italian State Railway along the Mediterranean coast from Genoa southwards had reached Spezia. It is now announced that on October 28th it was carried forward to Leghorn.

It is officially announced by the London, Midland and Scottish Railway Company that Mr. H. G. Burgess, the general manager, will retire on March 31st next, after fifty-three years' service. His office will not be continued, but Sir Josiah Stamp, the president, will have the assistance of four vice-presidents—Messrs. S. H. Hunt, J. Quirey, J. H. Follows and R. W. Reid.

When the London and North-Eastern extended its London–Leeds Pullman service to Bradford, the London, Midland and Scottish retaliated by the provision of a new express in the morning from Bradford at 9.10, which returned from St. Pancras at 4.55 p.m. Both trains have now been withdrawn. The connections to Liverpool on the 10.25 a.m., 12.25 p.m. and 4.25 p.m. expresses from St. Pancras to Manchester and the three corresponding trains from Liverpool to Cheadle Heath or Chinley have also been taken off. Obviously, these are a consequence of the necessity to reduce working expenses.

Another fatal railway accident occurred in France on Thursday, Oct. 28th. On this occasion the boat train from Boulogne which connected with the 2 p.m. from Victoria was involved. It appears that some wagons of a goods train were derailed at Liancourt, and in consequence all traffic had to be worked over the up line. On British railways the practice under such conditions would be to hold up all up trains at the box in the rear when a down train had possession of the single line. Apparently that was not done on this occasion, as when a down train for Lille was passing off the up line back on to the down line, it was run into by a train from Boulogne. Two passengers in the Lille train were killed.

Until 1911 there was no direct connection between the St. John's Wood lines of the Metropolitan at Baker-street and the Inner Circle lines. There was a trailing junction, but only for emergency use. All passengers from Wembley, Harrow, Uxbridge and the Rickmansworth direction for the City and *vice versâ* had to change trains and platforms at Baker-street. The laying-in of a proper junction allowed for the passage of through trains, and so successful have those been that from November 1st thirty additional trains have been running. Few people outside the railway are aware of the fact that when Baker-street Station was reconstructed at the date mentioned, provision was made to run the junction line from the City by a burrowing connection under the Circle lines.

The report by Major Hall on the collision of August 7th at Manors Station, Newcastle-on-Tyne, London and North-Eastern Railway, assigns, as was to be expected, the responsibility wholly to the motorman of the electric train. It will be remembered that the man tied up the "dead man" control, and, after he had been struck by the columns of an overbridge and dragged from the train his train ran without any driver, and, passing the protecting signal, collided with a goods train. The report assumes that the railway company will impress upon motormen their serious responsibility in this respect, and it then recommends that some better facilities be provided for the observation of signals by the guards of these trains. Those men at present can only see the signals by opening the sliding doors of their vans and looking out, and Major Hall proposes that at least drop windows in the vans be used.

The reconstructed station at Edgware-road on the Metropolitan Railway was opened on Sunday last. There are four running lines through the station which serve two island platforms. The outer are the main lines and the inner are loops. The connections are so laid in that a train from the west can enter the up main, up loop or down loop line, whilst a west-bound train can depart from either the down main, down loop or up loop line. Trains east-bound can leave from the up main, up loop or down loop. The additional accommodation thus provided has allowed the Metropolitan District Railway Company conveniently to exercise its running powers over the Inner Circle, and to extend its Putney Bridge–Earl's Court–High-street service over the Metropolitan to Edgware-road, and to make the latter station, instead of High-street, the exchange point. Some improvements have been made in the junctions at the latter station, and, at long last, the anomaly has been removed of having a Metropolitan signal-box and a Metropolitan District box opposite one another. The Metropolitan box has now been dispensed with and all work concentrated in the electro-pneumatic box of the District Railway.

We are sorry to see that one of the changes in the organisation of the London, Midland and Scottish Railway is the retirement at the end of the present year of Mr. Donald A. Matheson, the deputy general manager for Scotland. Since the death of Sir James Inglis, Mr. Matheson has been the outstanding example of a railway engineer becoming a successful general manager. After some years' experience in the construction of new railways, he came into prominence when resident engineer for the Caledonian Railway Company's underground railway in Glasgow, after which he became the Caledonian Glasgow divisional engineer and in 1899 succeeded the late Mr. George Graham as chief engineer. That position he held until the late Sir Guy Calthrop went to the Argentine in 1910, and then Mr. Matheson became the general manager. On the formation of the London, Midland and Scottish Company he was given charge of the Caledonian; Glasgow and South-Western and Highland railways as deputy general manager for Scotland. The principal work with which Mr. Matheson's name will be associated is the enlargement of the Glasgow Central Station, which work included a new four-track bridge over the Clyde and the subsequent reconstruction of the adjoining original bridge.

Notes and Memoranda.

An order placed in Greenock by a Bombay firm for some cargo steamers of about 8000 tons each, discloses a price of about £10 per ton deadweight.

The cost of developing the power of the Quareau River, at Rawdon, Quebec, is to be about 75 dollars per horse-power. The ultimate capacity of the plant will be 8000 horse-power.

According to *Canada*, the Britannia Mine in British Columbia is probably the largest copper mine in the British Empire, and is producing approximately 3,000,000 lb. of copper per month.

A note in *The Times* gives a brief description of what is described as a new process of manufacturing rubber that is being exploited in America. It appears that the broad principle is to deposit the rubber from an electrolyte of the latex on to moulds of the shape of the article to be made.

Three electric locomotives of the five ordered by the Harbour Commission from England, have arrived at Montreal on the Manchester Hero. With the new engines in service, the Commission will have nine locomotives in operation on its 65 miles of trackage. Electrification of the harbour terminals has been going on apace.

Hydrated lime in small amounts (less than 10 per cent.) increases the tensile strength of calcined gypsum, according to the American Bureau of Standards. A calcined gypsum-hydrated lime mix, rich in hydrate (in excess of 85 per cent.) has a greater tensile strength than a mix of like composition containing an equivalent amount of quicklime.

Experiments carried out by the Agricultural Education and Research Institutes, at Rothamsted, are said to show that if the share of a plough is electrified negatively it is persistently covered with a thin film of moisture, while it is at work. This very naturally reduces its frictional resistance to traction.

A flanged girder, built up by electric arc welding, was recently tested to destruction. It comprised a web $\frac{3}{8}$in. thick by 24in. deep, and flanges 12in. wide. One flange was $1\frac{1}{4}$in. thick and the other $1\frac{7}{16}$in. There were also cover plates $9\frac{1}{2}$in. wide and nearly as thick as the flanges. The estimated breaking load was 410 tons, but the maximum load was somewhat greater than this estimate. The welds connecting the web to the top flange failed at the ends only after the web was buckled and the girder had deflected several inches.

In a paper published by the Safety in Mines Research Board (No. 27) Mr. M. J. Burgess has described experiments on the distance over which a methane-air mixture, when exploded in a tube, projects its flame into the air filling a second tube attached to the explosion-tube. When the two tubes are 9 cm. in diameter the projection of flame into the air may be more than five times the length of the original column of explosive mixture. When the aperture between the two tubes is gradually reduced by an adjustable diaphragm, the first effect is an increase in the length of the projected flame, especially with mixtures containing an excess of methane. The experiments show to what a great distance flame may be projected along a gallery when a fire-damp explosion occurs in a mine.

It is stated in the *Iron and Coal Trades' Review* that Professor Dr. Bergius, inventor of the oil-from-coal process bearing his name, has uttered a warning against exaggerated hopes of the effect the process may have upon the present world-wide coal crisis. He pointed out that to produce 1,500,000 tons of oil, some three or four million tons of coal only would be required, as against a yearly output of some 200 million tons of coal in Germany alone. The oil-from-coal problem was essentially an oil problem, not a coal problem, and oil produced from coal would never be able to compete with natural oil from wells. There was a fear that the world's oil production from wells would eventually fall off considerably, and that scarcer supplies would increase the price of oil. This would be the time when the Bergius process might be able to come to the rescue.

The South African Government Mining Engineer, Sir Robert Kotze, speaking about accidents in the Rand mines, said that misfire accidents increased from an average of 37 in 1920–24 to 67 in 1925. The resultant deaths increased from 28 to 85 and the number of injured from 50 to 90. Statistics, relating to the percentage of misfired holes, he said, were not available. Since the abolition of the practice of blasting out and round separately, it had become customary in development work to light the holes for cut and round simultaneously. This had probably led to an increase of misfires in this class of work, since the cut holes were timed to go off first and their explosion must frequently result in blowing off the upper part of adjacent holes, including the primer of such holes. The rest of the explosives in such an adjacent hole might then remain as a misfire.

According to officially published figures of the latest census of the number of hydro-electric stations of over 300 nominal horse-power, in operation in Italy at December 31st, 1925, there were 588 with a combined total of over 2 million nominal horse-power capacity. At the same time 95 stations, with about 1 million nominal horse-power, were under construction. The reservoirs utilisable for the production of power were 86 in number, with a total capacity of over 800 million cubic metres, representing a nominal reserve when full of 1300 million kilowatt-hours. The effective value of this reserve in connection with existing plant, is estimated at 650 million kilowatt-hours. The reserve power obtainable from these reservoirs equals about one-tenth of that obtainable from the hydro-electric stations in operation—the production of electric power in 1925 being estimated at about 7000 million kilowatt-hours. The reservoirs still under construction number 27, with a total capacity of about 770 million cubic metres, and a nominal productive power of 1000 million kilowatt-hours. The conclusions drawn from these figures are that in a few years the power of the electric installations in Italy will have increased by 50 per cent., whilst the energy obtainable from the reservoirs will have augmented by 100 per cent.

Miscellanea.

Littlehampton harbour is to be reconstructed at a cost of £60,000.

A factory for the production of fireproof paints is to be put up at Sault Ste. Marie, Ontario.

The whole of the scheme for electric lighting in Galle, India, will probably be completed during December.

A wireless station is to be put up in Greece, for the Eastern Telegraph Company, by the Marconi Company.

The Bromley Ironworks, which were started over a hundred years ago, for the manufacture of slit nail rods, are to be demolished.

The Outarde Falls, in Quebec, which have a potential capacity of 50,000 horse-power, are to be utilised for driving a new paper mill.

The new great warehouse, which is to be put up on the water front at Montreal, will cost 5,000,000 dollars, and take about a year to erect.

The new foundry of the Warrington Light Casting Company, which has just been opened, covers an area of 3000 square yards in Napier-street.

The power plant of the Capetown Council is being extended by the addition of a 7500-kilowatt Metrovick turbo-alternator and Babcock boilers. Its capacity will then be 28,500 kilowatts.

In reference to the appeal for support for the Fleming Portrait Fund, to which we gave publicity recently, we are now informed that Sir William Orpen has consented to paint Professor Fleming's portrait.

Arrangements are being made for the development of the water power at Meductic, on the Saint John River, which is the only water power site of fair capacity remaining undeveloped in New Brunswick.

A 2ft. 6in. seam of coal has been struck at a depth of about 50ft. by men engaged in sinking a new pit at Bolton New Houses, near Wigton, Cumberland. It is expected to reach a 4ft. seam about 20ft. lower down.

The bore-hole which is being put down at Orallo, Queensland, in a search for oil, is down to a depth of 2600ft., and the Commonwealth Government is advancing £4000 more, so that it may be sunk to a depth of 4000ft.

Arrangements have been made for the exploitation of the nickel mines at Locris and in Boetia, by a British company. It has been stipulated by the Greek Government that the minimum output shall be 500 tons of nickel a year.

A message from Melbourne, dated November 1st, states the Full High Court, by a unanimous judgment, has found that the Commonwealth Shipping Board has no power to compete with private firms in the manufacture of electrical machinery.

A sixth section of wharfage for deep-draught vessels at Cairns Harbour, North Queensland, is under construction, at an estimated cost of £80,000. An electric travelling crane and other stationary cranes have been installed to deal with the heavy timber exports.

What is claimed to be a record was recently set up on the Rand when two Ingersoll jackhammers, in twenty-two shifts, between them drilled 1485 holes in a 32in. stope, an average of 33·7 holes per machine shift, as a result of which 413·5 fathoms of ground were broken.

The Queensland Government has decided to reopen the Chillagoe State Smelters, but the date upon which work will be resumed has not been decided. At present there are probably 25,000 tons of silver-lead ore, possibly more, available for crushing—enough to ensure a four or five months' campaign.

It is proposed to hold a provincial Agricultural Show and Exhibition of Cottage Industries at Jubbulpore from December 17th to 22nd, 1926. Demonstrations in the working of modern agricultural implements will be given to convince the agriculturists of the superiority of modern agricultural implements over their primitive tools.

According to a report from Port Nolloth, diamonds have been discovered on a coast farm some 37 miles south of that port. This extends the region over which discoveries have been made to over 50 miles, both north and south of the port. The stones generally are small and resemble those found north of the Orange River on the coast line of South-West Africa.

Sinking operations will, says the *Iron and Coal Trades Review*, shortly be started near the village of Mapplewell, South Yorkshire, where the Barnsley seam of coal has been proved. A good deal of the surface equipment has been erected, and will serve for the sinking as well. The shaft, which will be 18ft. in diameter, is to be sunk near the old ventilating shaft of the North Gawber Colliery, owned by Fountain and Burnley, of Barnsley, which firm is also responsible for the new enterprise.

A message from Lisbon says that the Minister of Commerce has submitted to the Cabinet a draft decree-law relating to the utilisation of water power for the production of electricity with the participation of the State. He also proposes to erect thermal electricity works near certain coal mines for the purpose of supplying power and light to Lisbon. The project for the utilisation of the Douro by Spain, which requires Portugal's approval, does not seem to be viewed with favour in Portugal.

The Crown Agents for the Colonies have, according to the *Iron and Coal Trades Review*, purchased a steamer for service in Nigeria, where she is to carry coal from the colliery down to Lagos. She is the third steamer to be put on this service, and some people have seen in her purchase the possibility of a Nigerian export trade in coal. This, however, is not at all likely. Nigerian coal is taken down to Lagos, where it is used for many purposes, including bunkers, but it cannot be said that it is popular among marine engineers. Its qualities are much the same as those of German coal that we are now having to import owing to the strike, while transport difficulties make its cost high. It is necessary to allow something like 25 per cent. of the ship's boiler power for the poor combustion and large quantity of ash.

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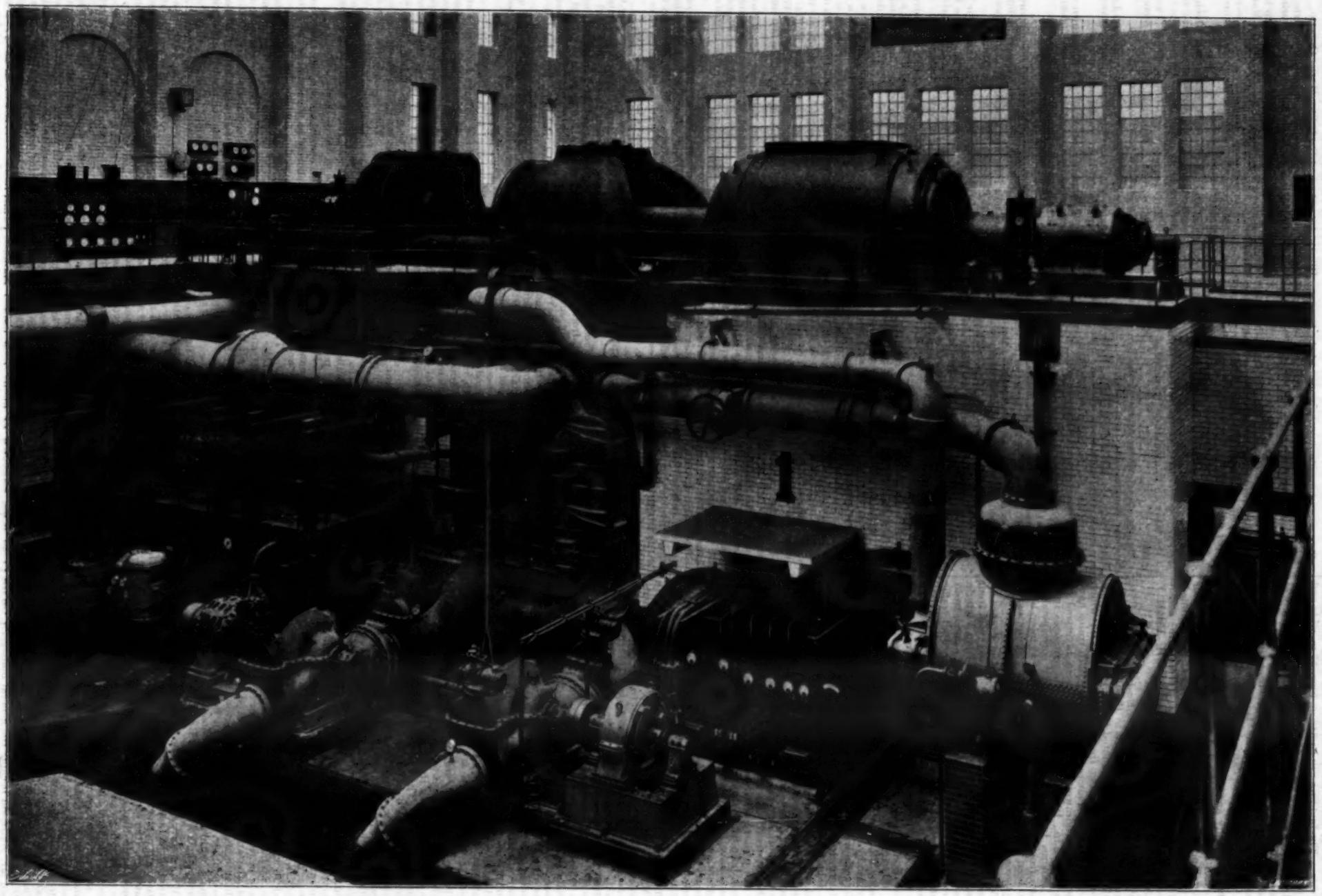

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THE ENGINEER.

NOVEMBER 5, 1926.

Prices and Markets.

It will be remembered that in March, 1925, the British Engineers' Association presented to the Government Committee on Industry and Trade a report on "The Present Conditions and Future Prospects of the Engineering Industry." That report was a notable publication, principally on account of the array of statistical tables and graphs which it contained. The basis of these tables and diagrams was the year 1913, which was taken as 100, and to it the data of industry in two, three or four preceding years were referred as percentages, either for prices or quantities. A few days ago the British Engineers' Association re-published the whole of that report with a new monograph on the economic situation of the British engineering industry at the present time. The figures for the first six months of 1926 have been added to the tables wherever they were available. The general survey of the engineering industries which is thus laid before us in statistical form has, of course, many dark patches. In 1925 the export in tonnage of machinery was 74·9 per cent. of the tonnage of 1913, but if the rate established for the first six months of the current year be continued to the end, then the tonnage for 1926 will be only 69·7 per cent., or 5·2 per cent. less than for 1925. Imports, on the other hand, which were 70·2 of the 1913 imports in 1925, will probably reach nearly 80 per cent. by the end of this year. Furthermore, the average value per ton of exports has fallen from 128·5 in 1922 to 93·28 for the current year as far as it has gone. Such facts as these do not reveal anything that was not anticipated. Indeed, if anything, we are more astonished to find that the engineering trade has succeeded in doing so much work, despite the grave difficulties under which it has laboured, than we are alarmed by the lowness of the figures. But that the position is bad is outside all question.

Turning now from the tables themselves to the monograph, we find Mr. Bremner insisting upon certain aspects of trade with which publicists in America and British publicists on American methods have already made us familiar. He observes that the total productive capacity of manufacturing countries is now considerably in excess of the needs of the markets at present prices. 'The disparity," he says, "between potential production and actual construction is so great that it is causing grave anxiety to leaders of industry in the principal manufacturing countries, more especially in Europe, because, unless the problem of increasing the market for their products at profitable prices can be solved, a large amount of machinery and plant will have to be thrown out of action and written off. In other words, large capital values will be destroyed, and large numbers of people thrown out of employment. These remarks apply, unfortunately, with special force to engineering and allied industry." The problem presented by such a state of affairs is a very curious one. The old economic law of supply and demand has gone, or is going, by the board. No longer does demand create supply. Under the impulse of mass-production methods manufacturers find themselves obliged to provoke a demand which does not naturally exist, and since in many cases the purchasers cannot command the necessary capital, an immense development of the instalment system of paying has taken place in America. Mr. Bremner appears to think that the same method must be employed in this country; but one has only to consider the alarm which it is causing amongst thoughtful Americans to feel that the policy has real dangers. The Americans themselves admit that if there were any great reverse of trade, or any prolonged stoppage of work which would prevent the workmen from paying their weekly or monthly instalments, many manufacturers would be involved in financial ruin. Against this point of view we must set the argument, advanced by many economists in America, that trade can be maintained by reducing the costs of manufacture and increasing wages, so that, as Mr. Ford says in his recent book, the employer's workmen become his best clients. Doubtful as we are of the soundness of that argument, even in self-contained America, we are far more doubtful that it can be safely and profitably used in this country, which must, perforce, depend in a very great measure upon its foreign trade. Mr. Bremner is, we are convinced, right when he says "improved salesmanship and increased credit facilities would help, but alone they could not increase the volume of engineering trade to the extent required to place it in a sound economic condition." The great, the essential need of the engineering and allied industries at the present day is the decrease of manufacturing costs. We appear to be receding from that object rather than approaching it. The false principles of restriction of output which are supported not by labour alone, but, unfortunately, in some cases by capital, have had and will continue to have an adverse effect upon all branches of industry. Let us say frankly that the employers who restrict output to retain prices at a high level whilst demand exists, are just as guilty of an infraction of the economic law as the workman who ca'n canny in the misguided belief that by so doing he can help a comrade. Restriction of output engenders a spirit of *laisser faire*, and by so doing hinders developments which ought to be made. Mr. Bremner is right in condemning cut-throat competition, but when avoiding that ill we must beware lest we fall into one even greater by removing competition altogether. There are two main economic sources which make for the development of industry. One is the increase of earnings, and the other is competition. The first becomes effective by enlargement of the market, and the second by excluding somebody else. It is at the former that we should aim. The markets open to British engineers are vast enough to find occupation at an economic load for all the factories in the kingdom; but until prices can be brought down to a point which will attract the purchaser, many of those markets, or the full extent of those markets, will not be secured. In several directions that truth is now being realised. We find, for example, propaganda directed by groups of competitive firms because they are aware that all may gain by the improvement of trade. Competition for orders there must be, but since the total number of orders may be increased there will be more orders to go round. Propaganda alone cannot attain the end in view; reduction of price in nearly all cases is essential. Obvious as this policy is, it has been neglected pretty generally by the leaders of labour, and we must admit in some cases by the leaders of industry. "It is generally true," says Mr. Bremner, "that reduced cost of production increases consumption, and that increased consumption reduces cost of production; but one of them must precede the other, and it is clear that in the case of the engineering industry reduced cost of production must come first." That is, we believe, the key to the revival of our engineering industries. The quality of British engineering products is not in question; there is no higher standard. Foreign nations, no less than our own Dominions, would gladly purchase from us, but in the face of prices ten, fifteen, even thirty per cent. lower than ours, they place contracts elsewhere.

"The only ways to meet this difficulty" (diminished

demand), says Mr. Bremner, "are to cheapen the products of engineering industry, to improve salesmanship, and to make the terms of payment easier for the purchaser." The problem of reducing sale price is acute. It is difficult to see where to begin upon it. In some engineering industries, notably motor car manufacture, the end is being achieved by improvements in organisation, as Mr. Perry-Keene, of the Austin Company, showed in a remarkable article which we published last week. It is, however, doubtful that reorganisation would have parallel effects in the heavy industries in which costs are controlled very largely by the price of raw materials. It would seem, almost, that the only chance is to begin by the reduction of the costs of metals. Many of our steel factories leave little or nothing to be desired as far as organisation is concerned. They are capable of producing cheaply in large quantities. But just when there seemed to be a chance that they might have an opportunity to employ their resources, the coal dispute threw them back again. Its inevitable result is to prevent a reduction, and probably to cause a rise in the cost of the raw materials of engineering manufacture. For the moment we seem to be fated never to get a start towards that decrease of manufacturing costs which is so greatly needed. If only we could begin somewhere, further reductions would follow and trade would revive. There is no question at all that the work is there to be done. The local competition of new countries which have recently taken up manufacturing may hit us in some degree, the international competition of foreign lands may increase our difficulties, but yet, we believe that the whole engineering capacity of Great Britain could be profitably employed if the short-sighted economics of many Labour leaders and of some manufacturers, traders and financiers were replaced by more liberal views.

Boiler Explosions and Water Gauges.

CONSIDERING the certainty of serious trouble if the water supply to a boiler be interrupted for a comparatively short time, it is rather remarkable that accidents due to shortness of water are not more numerous than they are. It is true that in important boiler installations automatic feed regulators and low-water alarms reduce the danger from a lapse of attention on the part of the firemen, but the great majority of boilers are not fitted with any such apparatus, and depend for the maintenance of their water level on the care with which they are operated. In a modern water-tube boiler a cessation of the feed for five or six minutes may result in the disappearance of the water from the gauge glasses, so that want of attention is liable to meet with swift retribution. So well is this recognised that in many power stations it is the custom to entrust the whole of the boiler feeding to one man with no other duties to distract him. Whoever is responsible has not only to keep a constant watch on his gauges, but to assure himself that they really indicate the conditions in the respective boilers. It is indeed probable that more accidents are due to faulty gauges than to lack of attention. The extent to which failure of water supply to boilers is accountable for serious trouble is indicated by figures given in the last technical report of the British Engine, Boiler and Electrical Insurance Company. During the 42½ years, ending December, 1924, since the coming into force of the first Boiler Explosion Act, out of 972 recorded explosions or collapses of boilers, no less than 189, or nearly 19·5 per cent., were attributable to "deficiency of water." As the total number of explosions or collapses referred to include 117 accidents to hot water boilers and 43 accidents to boilers classed as miscellaneous, they do not perhaps present a true picture of the case from an engineering point of view. By confining ourselves to boilers afloat, we can practically eliminate the influence of hot water boilers and such like articles of hardware on the figures, although unfortunately we eliminate the typical land boilers at the same time. Considering boilers afloat only, we find a total of 29 explosions and 156 collapses during the period in question. Of these, one explosion and 77 collapses, or 42 per cent. of the whole, were due to deficiency of water. No other single cause contributed nearly so largely to the destruction of the boilers. Corrosion, that great enemy of boiler plant, brought about 15 explosions and 18 collapses. Deposit was responsible for two explosions and 40 collapses, excessive pressure for four explosions and nine collapses, leaving only seven explosions and 12 collapses to be accounted for by structural weakness, failure of stays or unknown reasons.

That shortage of water remains one of the principal causes of serious boiler accidents is shown by the fact that of the eleven explosions or collapses recorded in 1924, no less than six were due to this factor. From the details of these accidents given in the report referred to, it is generally possible to learn why the water shortage occurred. The total number of accidents is too small to permit any general conclusions to be drawn from them, but the individual cases are worth studying, as each illustrates some form of human or mechanical fault which has led to disaster. The most serious accident of all, which resulted in four men being scalded to death and three others seriously injured, happened to a water-tube marine boiler working in a closed stokehold. Someone who had no business to do so shut the feed valve and forgot to open it again, with the result that the water in the boiler boiled away and the overheated tubes were drawn out of the headers. No one noticed the disappearance of the water, although the gauge glasses were illuminated by electric lights. A terrible penalty was therefore paid for an initial wrongful act, accentuated by forgetfulness and negligence. The only other water-tube boiler to fail by reason of water shortage was one in a chemical works. In this case one tube burst and two more were forced out of the drums. The deficiency of water in the boiler is said in the report to have been brought about by incorrect reading or registration of the gauge glasses. The latter were attached to the middle drum—the boiler was of the Stirling type—and as the middle drum as well as the front drum showed signs of overheating, it was concluded that misreading of the gauges by the fireman was the primary cause. In face of the evidence this is difficult to believe, yet no other explanation suggests itself. Prior to the accident, the fireman received instructions to blow the boiler down, and in order to get plenty of water to blow down, he opened up the feed valve. As the water did not rise in the gauge glasses, he tested the latter twice, the water, according to his account, returning to a level of 2in. after each test. A few minutes after the second test the tube burst. Now the gauges were certainly reading properly an hour or so before when 3in. of water was blown down. It would seem as unlikely for them to have gone wrong in the meantime as for the fireman to have twice mistaken a reading which he climbed up to the gauges to get. However this may be, the fact remains that on either supposition the boiler ought to have got too full rather than too empty, because all the time the feed valve was specially opened in order to increase the water contents of the boiler. The report overlooks this point. As there were four other boilers working off the same feed line, one can hardly suspect the availability of feed water, and so the explosion must remain without any really satisfactory explanation. For a gauge to be out of action, unknown to the boiler attendant, is obviously dangerous, and collapses of two marine boilers and one locomotive type boiler at sea are attributed to this cause. In the first case a combustion chamber collapsed, fortunately without injuring anyone. The gauge had been tested by blowing through in the usual way an hour or so before the collapse, and was then apparently all right. Ten minutes before the accident the gauge showed half glass, and two witnesses spoke to seeing several inches of water showing immediately after the collapse. A subsequent examination by the Board of Trade surveyor proved that the gauge was partly choked with a piece of packing material, and had indicated a false water level. The explanation of the collapse of the second marine boiler through water shortage was found to be that the boiler was put into service with one of the water gauge cocks shut, the gauge, of course, giving a false water level in consequence. In the case of the locomotive type boiler, the false reading was due to a piece of glass, the relic of a previously broken gauge, holding up the ball valve of the fitting. This accident would almost certainly have been avoided if the engineer had looked at the other gauge glass, which was in a shadowed position and not well lighted. The remaining case was one in which a combustion chamber collapsed, the probable explanation of the water shortage being that the engineer misread the gauge, owing to the rolling of the ship.

Of the six cases of collapse or explosion due to water shortage, there were therefore three in which the gauges were definitely inoperative. With regard to the others, possibly all could have been avoided by greater attention in reading the gauge glasses. No care on the part of designers will prevent accidents when, as in one case, a boiler is put to work with the gauge shut off. But designers may well take to heart the disasters caused by the stoppage of the gauges by packing, broken glass, &c., with a view to reducing the risk of accidents from this cause. Nor, in general, can designers wash their hands of the responsibility attaching to them when gauges are misread. In such cases the first impulse is to blame the operator. If he could read the gauge correctly before the disaster, why could he not do so on the fatal day? Again, if other men can operate a boiler safely with such gauges, why could not he? But such questions may not be at all just. The importance of a water gauge is such that there should be no possibility of misinterpreting it either by night or day. An ideal water gauge should proclaim the water level at all times in such a way that he who runs may read, forcing its information on the attendant rather than demanding scrutiny on his part. Instead of being a bold-looking apparatus, fit to take its place with modern pressure gauges, steam flow meters, CO_2 indicators and other boiler house instruments, the water gauge in a power station has, often enough, to be sought for before it can be seen, away up 20ft. or 30ft. above the firing floor, and half hidden by galleries and ladders. It is true that more or less effective illuminating devices assist in rendering the water level visible, but it is equally true that few water gauges are as easily legible as they ought to be. The tendency towards higher steam pressures does not make the question of producing a good water gauge any more simple. We recently saw a high-pressure gauge in which the flat glass was only visible through a narrow slot in a thick metal plate, which held it. The plate was fastened by a number of nuts at each side of the slot, and the latter was not even flared out, so that the glass was quite invisible to anyone who was not almost directly in front of the instrument. The designer had been wantonly regardless of the first essential of a gauge, namely, that it should be easily read, for quite equal strength could have been obtained consistently with a more intelligent design. The great height of modern boilers is one of the drawbacks to the easy reading of water gauges. If a man remains at the drum level to control the feed, he cannot generally command an adequate view of gauges other than those in his immediate neighbourhood. The problem is really to make the gauges more visible from the firing floor, and several attempts have been made to solve it by the use of distant-reading water gauges, which can be placed at about the level of the fireman's eyes, independently of the height and position of the boiler drums. The simplicity and directness of the ordinary water gauge have, of course, to be sacrificed, but the compensating advantages are so great that if the new gauges are found to be trustworthy in practice a great development in this direction is to be looked for.

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University of London College Calendar, Session 1926–7. London: Taylor and Francis, Red Lion-court, Fleet-street, E.C. 4.

The Motorship Year-book. Fourth edition. New York: "The Motorship," 220, West 42nd-street, N.Y. Price $3·00 net.

Unemployment. By G. W. Mullins. London: Longmans, Green and Co., Ltd., 39, Paternoster-row, E.C. 4. Price 6s. 6d. net.

Transformateurs. By R. Carton and P. Dumartin. Paris: Librairie Armand Colin, 103, Boulevard Saint-Michel. Price 9·80 fr.

Kelly's Directory of Engineers, Iron, Metal and Motor Trades, 1926. London: Kelly's Directories, Ltd., 186, Strand, W.C. 2. Price 45s. net.

Erddruck, Erdwiderstand und Tragfähigkeit. By H. Krey. Berlin: Wilhelm Ernst and Sohn, Wilhelmstrasse, 90, W. 66. Price 21·60 R.mk.

Der Genauigkeitsgrad von Flügelmessungen bei Wasserkraftanlagen. By Professor Dr.-Ing. A. Staus. Berlin: Julius Springer, Linkstrasse 23/24, W. 9.

Supplement to an Introduction to Sedimentary Petrography. By H. B. Milner. London: Thomas Murby and Co., 1, Fleet-lane, Ludgate Circus, E.C. 4. Price 9s. 6d. net.

Alternating-current Rectification and Allied Problems. Second edition. By L. B. W. Jolley. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C. 2. Price 30s. net.

The Steam Engine and Other Heat Engines. Fourth edition. By Sir J. A. Ewing, K.C.B. London: The Cambridge University Press, Fetter-lane, E.C. 4. Price 25s. net.

Battleships in Action. Two volumes. By H. W. Wilson. London: Sampson Low, Marston Company, Ltd., 100, Southwark-street, S.E. 1. Price 42s. net for the two volumes.

The Gasoline Engine: Being Volume I. of the Gasoline Automobile. Seventh edition. By P. M. Heldt. London: Iliffe and Sons, Ltd., Dorset House, Tudor-street, London, E.C. 4. Price 40s. net.

Models and Analogies for Demonstrating Electrical Principles.

No. XIII.*

At the Marconi Company's Wireless Engineering School at Chelmsford a mechanical synthesiser has been developed by the superintendent of instruction, Mr. A. W. Ladner, for the demonstration of wave synthesis generally. In particular the machine is of use to help with the explanation of modulated waves, where a knowledge of the envelope is of the first importance and for which mathematics is so inadequate. It consists briefly of a mechanical device for integrating instantaneous values of a number of harmonic motions. The principle on which the model works is that adopted by Lord Kelvin for his tide machine, namely, integration by a connecting cord. The integrating cord, one end of which is held, can be seen in Fig. 116, and it passes successively over the loose pulleys on the component cranks and finishes on the integrating arm B, the other end of the arm being pivoted at O.

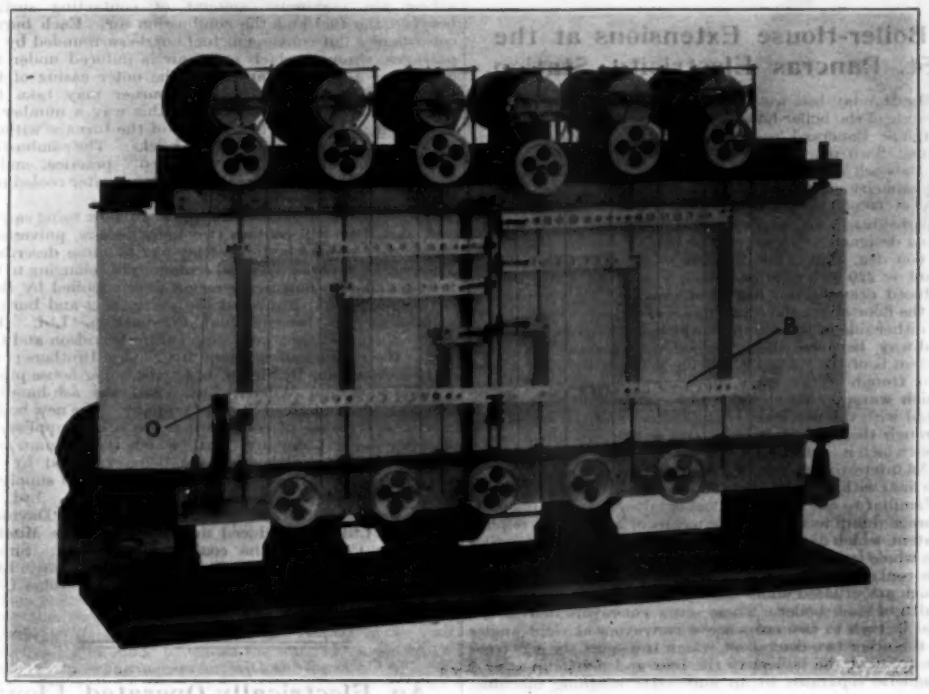

FIG. 116—MECHANICAL SYNTHESISER

The component harmonic motions to be added—in this model up to six in number—are provided by crossheads driven from continuously rotating cranks and these six disc cranks with their crossheads are seen at the top of the machine. Attached to each crosshead is a loose pulley over which the cord passes, and an infinite connecting-rod which carries an extension arm holding the marking point for tracing the component frequency on the indicator paper.

Thus the latter will give an accurate trace of the component harmonic motion. Any amplitude up to 1in. and any frequency within reason can be obtained on any component, and a fairly rapid means of changing values is provided. It is easy to see how the machine operates. The rotation of a crank causes its crosshead to move harmonically in a vertical plane, and thus the attached loose pulley rises and falls in the same manner. Thus if one end of the integrating cord is held, since it passes over all the loose pulleys in turn, the motion of the free end vertically gives twice the sum of the motions of any of the component crossheads working, and thus the movement of the arm traces the synthesis curve. Since the end of the arm gives a result double the correct amplitude, the marking point of the synthesis curve is placed halfway along the arm and thus comes into line with the marking points of the components. It will be noticed that, simultaneously with the tracing of the resultant wave by the arm, each component also makes its trace, and as all the pencils have been brought into line, all traces commence at the same position on the time base, this feature being a very important one for demonstration work.

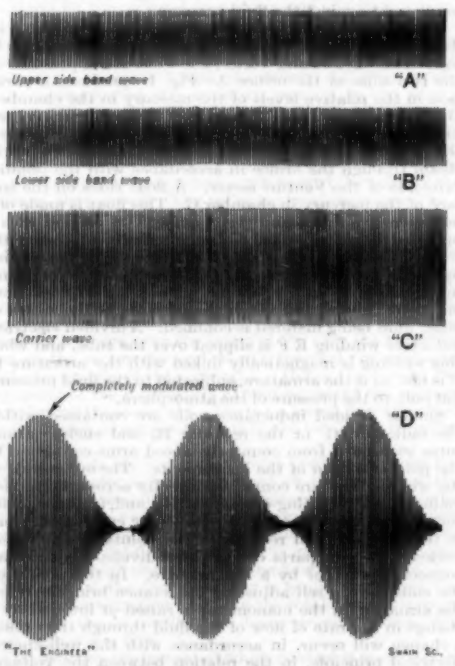

FIG. 117—COMPLETELY MODULATED WAVE

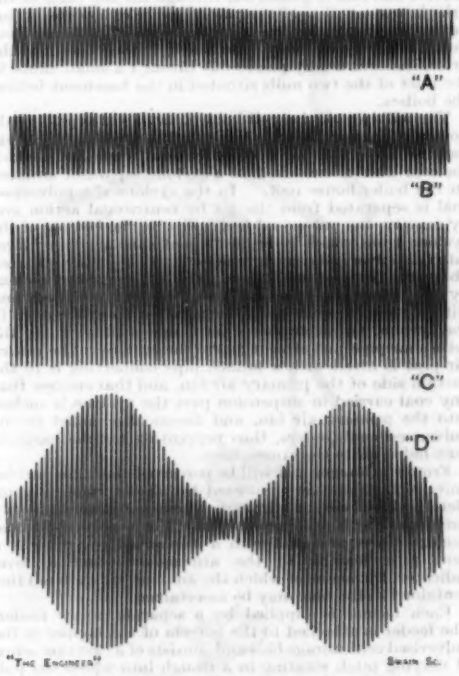

FIG. 118—EFFECT OF OVER MODULATION

The vertical board behind the link work provides a surface across which the indicator paper can be pulled and a polished ebonite roller is used to press the paper perfectly flat against the board as it passes the marking points. The drive for the paper is provided by a separate motor in order that a big variation of paper speed can be obtained without altering the curve being produced, so that the various curves can be studied from different aspects. A rotating table has now been incorporated with the machine so that polar representation can be obtained at the same time as the linear, but this table is not shown in the illustration Fig. 116.

Having given a brief description of the machine, we will now turn to its use. The modulation of radio frequency waves by a signal is a subject that is always difficult to visualise and expound with any satisfaction, and the usual pictorial method, whilst it is the only way of conveying a mental picture of the subject to non-mathematical minds, is liable to create false ideas on certain points. By building up a modulated wave mechanically and by studying its features much clearer impressions may be given.

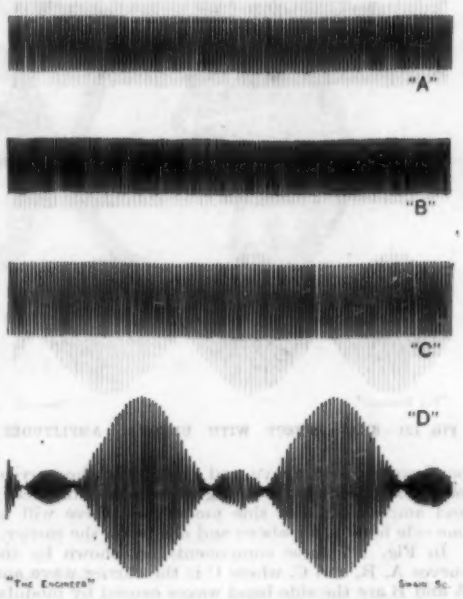

FIG. 119—EFFECT OF UNDER MODULATION

The representation of a modulated wave by a sine signal is familiar to most of us and is shown at "D" in Fig. 117, from which it would appear that a modulated wave is simply one of constant frequency and varying amplitude. If such were the case, since it is a single frequency, it would only be necessary to provide a receiving system with a filter band of width to take that frequency alone whatever the modulation. That, of course, is known to be incorrect, and it must be concluded that, although the pictorial wave may give a correct representation of the results achieved, it is not a complete representation.

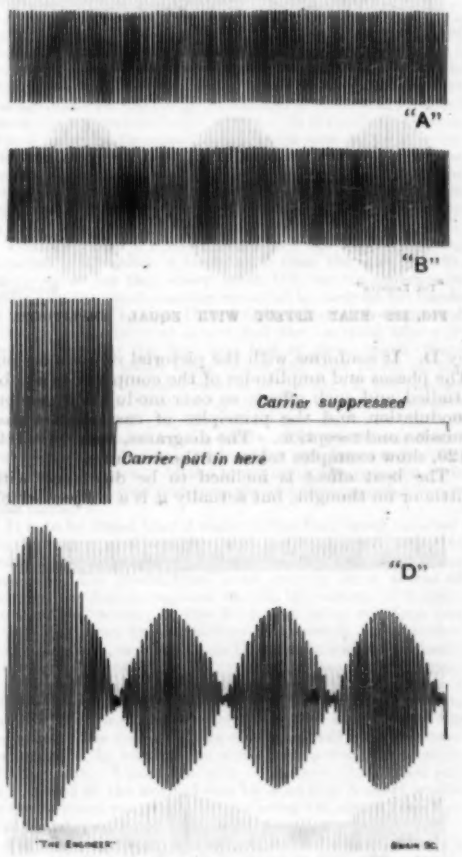

FIG. 120—CARRIERLESS TRANSMISSION

It may be shown mathematically that the result of

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modulation on a constant carrier wave is to bring into being new frequencies, and that the pictorial wave is in reality a synthesis wave caused by the heterodyning of these frequencies with one another. Thus a modulated wave must be considered as a spectrum made up of two essential parts : (*a*) a carrier wave determining the (mean) wave length of communication, of constant frequency and amplitude ; and (*b*) two sets of side

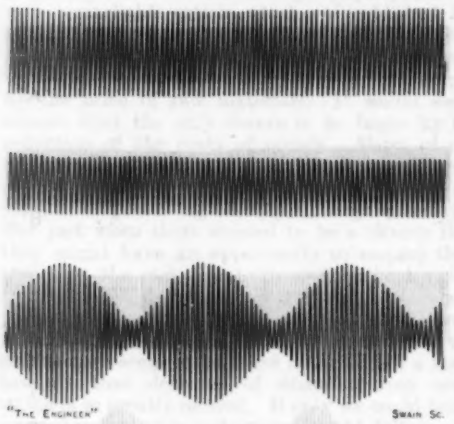


FIG. 121—BEAT EFFECT WITH UNEQUAL AMPLITUDES

band waves, one above and one below the carrier, each component wave being of constant frequency and amplitude. For sine modulation there will be one side band wave above and one below the carrier.

In Fig. 117 these components are shown by the curves A, B, and C, where C is the carrier wave and A and B are the side band waves caused by modulation, the resultant modulated wave being as shown

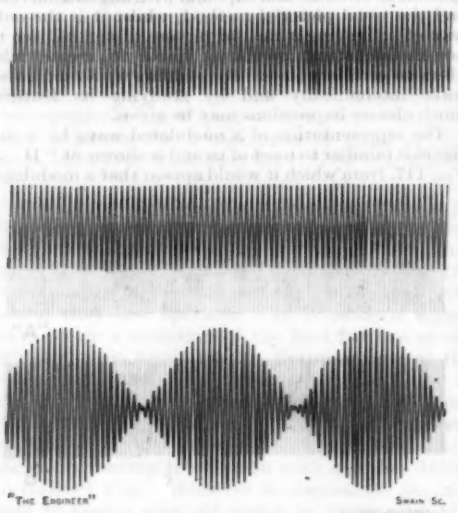


FIG. 122—BEAT EFFECT WITH EQUAL AMPLITUDES

by D. It conforms with the pictorial representation. The phases and amplitudes of the components can be studied and such effects as over-modulation, under-modulation and the principles of carrierless transmission and reception. The diagrams, Figs. 118, 119, 120, show examples taken on the machine.

The beat effect is inclined to be dismissed with little or no thought, but actually it is a subject which

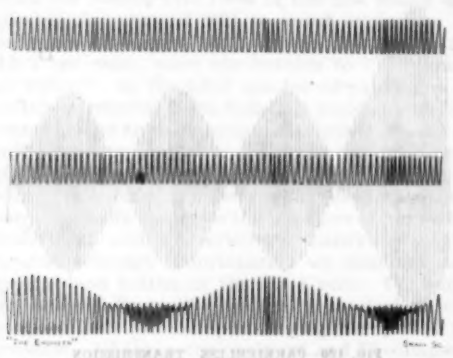


FIG. 123—BEAT EFFECT OF TWO RECTIFIED FREQUENCIES

is full of interest and can be studied in great detail by this machine. To commence with, in radio work we are concerned chiefly with the envelope obtained after rectification, and the mathematical expression for a rectified envelope is a complex function and is therefore not easy to analyse. But with a mechanical device the envelope can be obtained without difficulty and hence studied from various aspects, and the diagrams Figs. 121, 122, and 123 show samples of beat curves, the first two samples showing the change in character of envelope produced by an alteration of relative strength of the beating waves. The diagram given in Fig. 123 is a freak and is the result of beating together two rectified frequencies, and ardent mathematicians can amuse themselves by working out the expression for the envelope of this example.

The machine may be used for obtaining the synthesis curve of an ordinary fourier series, and innumerable examples of this type of curve can be studied.

Boiler-House Extensions at the St. Pancras Electricity Station.

On Monday last we were invited to attend the official opening of the boiler-house extensions at the power station of the St. Pancras Electricity and Public Lighting Department. Two new water-tube boilers have been supplied by Babcock and Wilcox, each having a normal evaporating capacity of 40,000 lb. per hour, and an overload capacity of 60,000 lb. per hour. Each unit has an integral superheater, and superposed economiser, the former being designed to impart a final temperature to the steam of 655 deg. Fah. The normal working pressure of the plant is 220 lb. per square inch. An electrically driven induced draught fan has been provided for each boiler on the floor above the economisers and the fans are placed on either side of the chimney, which is situated on the roof mid-way between the two boilers. The ash-handling system is of the "Usco" sluicing type, comprising a cast iron trough under each combustion chamber, through which water is circulated. The combustion chamber is fitted with the necessary scaling doors and the ash passes through these to the trough and is delivered to a sump from which it is extracted by a grab.

An interesting feature of the new plant is that the boilers are fired with pulverised coal on the Lopulco system, which is familiar to our readers. Coal is taken from the raw coal storage dump in the yard by means of a grab and telpher system, which discharges into a raw coal bunker extending the whole length of the boiler-house, and from this bunker the coal passes through gates into two screw conveyors, which are situated under the bunker and extend the whole width of each boiler. These screw conveyors deliver the coal in turn to two cross screw conveyors at right angles to the other two conveyors, which transport the coal from the front of the boilers to the rear and deliver it over a magnetic separator to an automatic weighing machine. The magnetic separator serves to prevent any tramp iron entering the mill. From the weighing machine the coal passes to a reciprocating tray feeder and from thence into the boot of a small elevator, which conveys the fuel up to the top of the drier, into which it is fed through a small chute. So far as the raw coal-handling equipment is concerned, each boiler is complete in itself, there being two screw conveyors, one magnetic separator, one weighing machine and one elevator per boiler unit.

The two driers are of the "Lopulco" waste heat louvre type. The coal is fed in at the top and falls by gravity between two sets of steel louvres, whilst the flue gas is drawn by means of a low-pressure fan from the chimney and enters the top of the drier at the side. The hot gas passes through the thin layers of coal falling through the louvres and finally passes out through the top plate of the drier into an auxiliary flue situated at the rear of the boiler-house basement, the flue being connected to the existing dust destructor chimney. On reaching the bottom of the drier, the coal finally passes out through a small chute to the inlet of the two mills situated in the basement behind the boilers.

The mills are of the well-known Raymond type, and do not call for description. Each mill is fitted with an exhauster fan and an air ducting system by means of which the coal dust is conveyed to a cyclone separator situated on the boiler-house roof. In the cyclone the pulverised coal is separated from the air by centrifugal action and by gravity, the pulverised fuel falling to the bottom of the cyclone from which it is discharged through flap valves into the pulverised coal storage bunkers, which are situated above the front of the boilers. The air leaves the cyclone by the return air pipe and re-enters the pulveriser, and with a view to preventing the building up of pressure in the system, an atmospheric vent pipe is provided in the return air pipe just after it leaves the cyclone. The return air pipe is fitted with a branch pipe connecting it to the suction side of the primary air fan, and that ensures that any coal carried in suspension past the cyclone is sucked into the primary air fan, and thence discharged to the pulverised coal feeders, thus preventing the discharge of dust-laden air to the atmosphere.

From the foregoing it will be perceived that the various units of each set are connected by pipes forming a completely closed circuit, through which air is continuously circulated by the exhauster fan. Each pulverised coal storage bin is provided with a dust-proof cover plate, a vent pipe leading to the atmosphere, and a level indicator, by means of which the amount of powdered fuel contained in the bins may be ascertained.

Each burner is supplied by a separate screw feeder. The feeder is attached to the bottom of the hopper of the pulverised coal storage bins and consists of a cast iron screw of varying pitch rotating in a trough into which the pulverised coal flows by gravity. The coal is propelled forward by the rotation of the screw into the shrouded portion of the feeder, at the outlet of which it meets the primary air introduced under pressure through a separate connecting pipe. The function of the primary air, which constitutes approximately 15 per cent. of the total combustion air, is to convey the fuel to the burner and to ensure a uniform and uninterrupted flow. The primary air and the pulverised fuel are intimately mixed at the outlet from the feeder by a rotating paddle. There are five burners to each combustion chamber and five corresponding feeders are arranged in two groups, one group containing three feeders and the other group two feeders. These groups are driven respectively by a 4 horse-power and 3 horse-power variable speed motors, enabling the feeder to be run at a speed varying between 35 and 140 revolutions per minute. Each feeder screw is operated through a clutch and worm gear running in oil. Isolating valves are provided by means of which individual feeders may be put out of action. Each feeder is connected to its burner by a wrought iron pipe and one primary air fan is provided for each group of five feeders, each fan being driven through a flexible coupling. The fans are situated just above the burner gallery, and the air is drawn partly from the top of the furnace arch, which acts as a pre-heater, and partly from the return air pipe from the cyclone collector to the mills. The primary air fan discharges into a header fitted with five branch pipes, one to each feeder.

Five "Lopulco" burners are fitted to each combustion chamber, and they are designed with a view to providing the maximum amount of contacting surface between the fuel and the combustion air. Each burner consists of a flat convergent fuel nozzle surrounded by air passages, through which extra air is induced under the control of a pair of dampers. The outer casing of the burner is designed so that the burner may take the place of a standard arch, and in this way a number of burners may be fitted to the arch of the furnace without involving the use of special or cut bricks. The combustion chamber follows standard "Lopulco" practice, and is provided with the usual water screen and water cooled rear wall elements.

Additional boiler-house extensions are now being carried out, and they will contain two more boilers, pulverising plant, &c., similar in general lay out to those described. The boilers, superheaters and economisers belonging to the new installation now in operation were supplied by Babcock and Wilcox, Ltd., and the pulverising and burning equipment by International Combustion, Ltd. The induced draught fans were supplied by Davidson and Co., Ltd., the coal-handling plant by Naylor Brothers ; the weighing machine by Simon, Ltd.; the boiler-house piping by Babcock and Wilcox, Ltd.; and the ash-handling plant by the Underfeed Stoker Company. The new boilers now in the course of construction are being supplied by Vickers Boiler Company, Ltd., which is the main contractor. The superheaters are being supplied by the Power Speciality Company, Ltd., which is also supplying the economisers. International Combustion, Ltd., is supplying the pulverising burning equipment ; Davidson and Co., Ltd., the induced draught fans ; the Mitchell Conveyor Company, the coal-handling plant ; Simon, Ltd., the weighing plant ; Vickers Boiler Company, Ltd., the boiler-house piping ; and the Underfeed Stoker Company, Ltd., the ash-handling plant.

An Electrically-Operated Flow Meter.

The instrument illustrated herewith is an electrically operated meter for indicating, recording or integrating the rate of flow of steam, water, air, gas or other fluid. Electrically operated appliances of this description are not new, but for the design illustrated the makers, the Brown Instrument Company, of Philadelphia, U.S.A., claim certain important advantages. The meter, it is stated, is so designed that fluctuations in the voltage of the current supplied to it are without effect on the readings, and as a consequence no voltage regulator is required. All the electrical parts and connections are external to the pressure chamber, there are no electrical contacts dipping into mercury, and there are no bushings which have to be made tight against the fluid pressure.

The electrical principle employed is that of the "inductance bridge." When the rate of flow of the fluid to be measured, say, steam, varies, the differential pressure on the two sides of the orifice A—Fig. 1—produces a variation in the relative levels of the mercury in the chambers B C. With an increase in the rate of flow the mercury level in chamber C falls, and *vice versâ*. The difference between the mercury levels is a measure of the rate of flow of the steam through the orifice in accordance with the familiar principle of the Venturi meter. A float rides on the surface of the mercury in chamber C. This float is made of a non-corrosive metal and the chamber C is formed with a moulded bakelite lining, ribbed internally to ensure the free action of the float. A non-magnetic rod extending upwards from the float carries an armature D of transformer iron, which is housed within a rustproof non-magnetic tube within which the pressure of the steam or other fluid being metered is confined. A divided electrical inductive winding E F is slipped over the tube, and while this winding is magnetically linked with the armature D, it is not, as is the armature, subjected to the fluid pressure, but only to the pressure of the atmosphere.

Similar divided inductance coils are contained within the indicator G or the recorder H, and enclose armatures suspended from counterbalanced arms connected to the pointer or pen of the instruments. The outer ends of the winding E F are connected directly across the service mains of an alternating-current supply, and, from the main, connections are also taken to the outer ends of the coils in the indicator and recorder. The points of connection between the two parts of the three divided coils are all connected together by a neutral wire. In this condition the coils form a self-adjusting inductance bridge. When the armature in the manometer is raised or lowered by a change in the rate of flow of the fluid through the orifice, a change will occur, in accordance with the well-known electrical principle, in the relation between the voltages across the two parts E F of the divided coil in the manometer. As a result, the currents in the two parts of the indicator and the recorder coils will become unequal, and the armatures of these two coils will move to new positions corresponding with the position of the armature in the manometer. Since the positions assumed are such that the relative voltages across the two parts of each coil are the same, the operation of the instrument is independent of the actual value of the voltage in the supply mains. No current flows in the neutral wire, and the currents in the halves of each divided coil are equal, except when the armatures are moving.

The movement of the armatures is, strictly, proportional to the difference between the pressures on the two sides of the orifice. The rate of flow is proportional to the

square root of this difference of pressure. The movement of the indicator pointer and of the recorder pen has therefore to be read against a scale, the divisions of which are unequal and diminish towards the zero graduation. To integrate the rate of flow in order to obtain a progressive indication of the total volume of fluid that has flowed through the orifice since the integrated quantity was last read, it is essential to obtain a movement which is proportional to the square root of the armature movement.

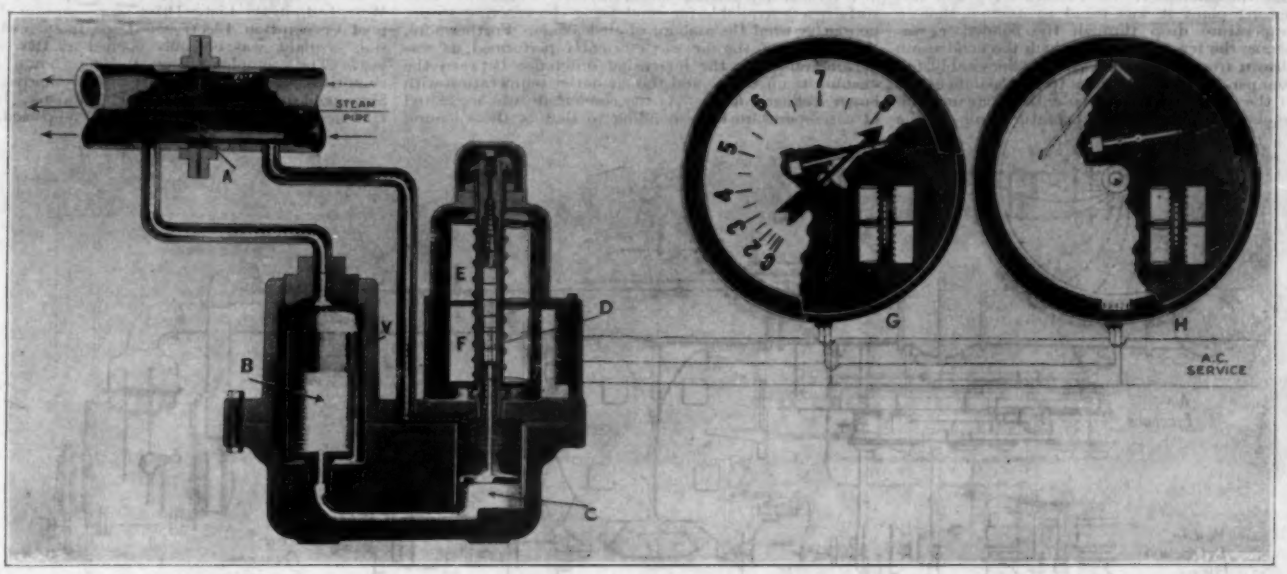


FIG. 1—ELECTRICALLY-OPERATED FLOW METER WITH INDICATOR AND RECORDER

Such a derived movement will be proportional to the rate of flow and may be made the basis of a mechanical integration process involving a clock as part of the mechanism. Since the circular chart of the recorder instrument is provided with a clock drive, the integrating device can conveniently be made to utilise the same clock drive and be combined in one instrument with the recorder.

The principle of the integrating mechanism is illustrated in Fig. 2. The sector J is driven at a constant rate by the clock mechanism of the recorder. The roller K is held out of contact with the sector by means of the latch L. The latch is tripped when the sector is in different positions, with the result that the roller K before the sector turns away from beneath it makes a greater or a fewer number of turns, according as the latch trips earlier or later. The moment at which the latch trips is determined automatically by the rate of flow, the tripping occurring earlier with a large than with a small rate of flow. Before the roller leaves the sector, it is by this means caused to turn through an angle which is proportional to the prevailing rate of flow. After the roller passes off the sector it is automatically relatched ready for the next tripping.

The integration, it will be gathered, is not a continuous process. It is assumed that during the period of time t occupied by the sector J in making one complete revolution, a period which is constant, the quantity of fluid passing the orifice per second remains at the value it possesses over the portion t/n of the period t during which the roller is in contact with the sector. In other words, it is assumed that the quantity passing in the time t is correctly proportional to θt, where θ is the angle turned through by the roller in the interval t/n. On this assumption, since the interval t is constant, the total quantity passing the orifice during any extended period T will be proportional to the aggregate angle turned through by the roller in that period. The roller is therefore coupled to a counter of the cyclometer type or to some other form of cumulative indicator.

From this description of the integrating principle employed it would appear that if the flow is rising the angle turned out by the roller in the interval t/n is proportional not to the average flow during that interval but to the flow in existence at its start, that is to say, a flow less than the average over the interval t/n. By the construction of the sector the end of the interval t/n coincides with the middle of the interval t. Hence the flow at the beginning of the interval t/n cannot represent the average flow during the interval t. During a rising flow the effect would therefore appear to be that the total flow is underestimated.

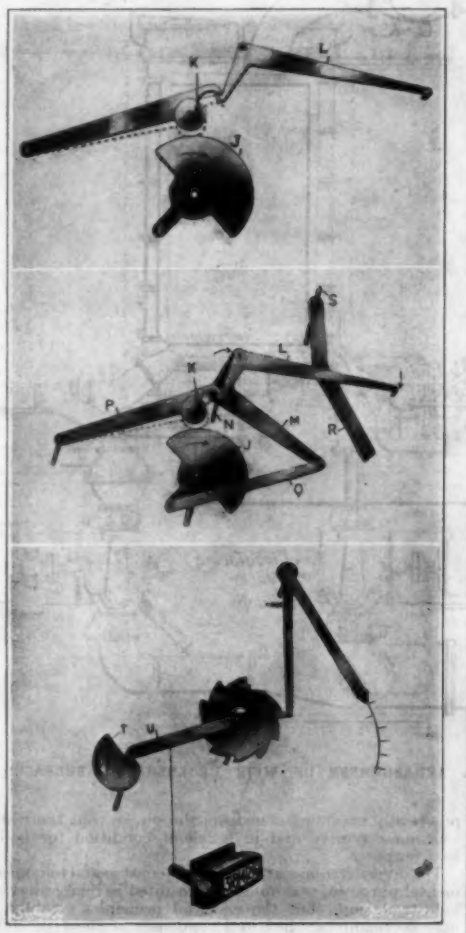
Again, while the instant at which contact between the roller and sector is broken is fixed at the middle of the interval t, the instant at which contact is made precedes the middle by a varying amount, being earlier as the flow is greater and later as the flow is smaller. It would appear therefore that the underestimation is greater with a rising flow which is high than with a rising flow which is low.

Similarly, if the flow is falling it would seem that the principle of integration results in the total flow being overestimated, the overestimation being greater with a high than with a low flow.

Theoretically the instant at which contact is made should coincide with the middle of the interval t, and the instant at which contact is broken should be varied in accordance with the flow. This condition requiring the tripping of the latch at regular intervals and the rotation of the sector at a variable rate would no doubt greatly complicate the construction of the device.

The magnitude of the discrepancies introduced by the factors we have mentioned is not known to us. It is quite possible that with any practical rate at which the flow can increase or decrease they may be negligible. If the flow is fluctuating the discrepancies tend to cancel one another.

The tripping mechanism is shown in Fig. 3. The latch L, it will be seen, is pivoted on a bell crank lever M, which is mounted on an axis N with which, when the latch is set, the latching point of the lever P carrying the roller is coincident. The lever M may therefore be oscillated on its axis N without delatching the roller lever P. Regular oscillation is imparted to the lever M by means of the link Q coupling it to the arm of the rotating sector J. As this sector rotates the long arm of the latch L swings up and down about the axis N without delatching the roller lever. Tripping of the roller will occur on the downward stroke of the latch L, if during this stroke the end of the latch strikes against the blade R. This blade is fixed on the axis S of the recording pen arm. When the recorder is indicating zero flow the latch just escapes striking the tripping blade. As the flow increases the blade R moving with the recorder pen arm trips the roller at an earlier and earlier period in the downward stroke of the latch L. In this way the instant at which the roller is tripped and brought into contact with the sector J is made to depend upon the position of the recorder pen arm, that is to say,



FIGS. 2-4—INTEGRATING MECHANISM

upon the prevailing value of the flow through the orifice.

It will be understood that the tripping action reacts on the blade R and, unless steps were taken to prevent its doing so, would produce a movement of the blade and the recorder pen arm other than a movement due to a change in the rate of flow through the orifice. To obviate this result the long arm of the lever M is provided at its end with a roller, which at the moment of tripping passes across the blade R and holds that blade fast against a plate while the tripping is taking place. The interference so caused with the free motion of the recorder pen arm is only momentary.

The angular movement of the recorder pen arm and therefore of the blade R is proportional to the difference of pressure on the two sides of the orifice. Hence, in accordance with the familiar law, the rotation of the roller K in order that its movement may be directly proportional to the volume of the flow, must be proportional to the square root of the movement of the blade R. This relationship, it is claimed, is very approximately secured, during the effective downward part of the motion of the latch, by the kinematical consequence of the manner in which the bell crank lever M is driven from the constant speed shaft on which the sector J is mounted. A slight departure from the exact relationship desired is corrected by the shape given to the tripping blade R.

The re-setting of the trip motion is produced once during each revolution of the sector J by the contact of the crank arm on the sector with the underside of the roller lever P.

The principal portion of the mechanism employed to transmit the angular movement of the roller K to the cyclometer counter, and to a pen arm—which may be arranged to record the integration round the edge of the chart on which the rate-of-flow recorder pen arm works—is shown in Fig. 4. When the roller K has completed a definite number of revolutions a pawl, not shown, is caused to engage with a pinion of the chart driving gear. As a result, the cam T is caused to make one complete revolution and then stop, ready for another revolution when the roller has again completed the given number of turns and the pawl has again engaged with the pinion. As the cam rotates the arm U is gradually raised, and lifts the arm of the counter The sudden fall of the arm U after the high point of the cam is passed advances the reading of the counter by one unit. It is claimed that the figures of the counter cannot pause in a half-way position that would result in ambiguity in their reading.

The integrated flow recorder pen arm operates by making a radial tick outside a circle each time the arm U falls, except in so far that every tenth tick for convenience in adding up the total quantity recorded is made on the inside of the circle. The arm U, it will be inferred, is connected through a ratchet with a serrated disc carrying nine saw teeth. Between the first and last of these teeth, there occurs a tenth tooth lying below the root circle of the others. On the upward motion of the arm U the ratchet comes into action, but during the quick downward motion the serrated wheel is rapidly turned anti-clockwise through the angle subtended by one tooth. The pen arm is therefore moved out and in, and leaves a tick beyond the base circle on the chart. At the tenth tooth the pen arm, it is clear, will be moved first inwards and then restored to the base circle.

It is to be noted that if water is the fluid being metered, the indicator and recorder may be graduated either in cubic feet or in pounds. If, however, air or steam is being measured, the graduations must strictly be in terms of volume, the factor required for the conversion to weight, namely, the density of the fluid, not being constant but depending upon the variations of pressure. For boiler-house purposes, or in other applications in which the elastic fluid being metered has some more or less constant particular pressure, the graduations can be made in terms of weight if the prevailing pressure is known. If the flow is subject to a considerable change at some time—say, a big reduction—the record left on the chart will alter in size—for example, be confined to a small area round the centre of the chart. Under the new conditions the record can be restored to the normal size by inserting a chart scaled to the reduced range and by replacing the stand pipe V—Fig. 1—by another of wider bore.

For metering steam the apparatus is made to cover six ranges, the first of which is designed to deal with a maximum pressure difference of 1·6in. of mercury, and the last a maximum difference of 16in., the steps progressing by about 60 per cent. at a time. For other purposes the apparatus is made to give the full recorder pen deflection with a pressure difference as low as ½in. of water. The operating force is, however, the same in the high-sensitivity series as in the high-range series.

The agent for this flow meter in Great Britain is the Lovick Johnson Company, 5, Montana-road, London, S.W. 17.

A Large Regenerative Surface Condensing Plant.

In recent designs of large surface condensing plants such as are now required to meet the more exacting requirements of modern turbine practice, attention has been paid, not alone to the production and maintenance of higher vacua, but also to the most important factor of temperature drop through the condenser. In the earlier types of surface condensing plant it was usual to assume that a certain temperature drop through the condenser was unavoidable, as the temperature at which the condensate could be drawn from the condenser must inevitably fall below the temperature corresponding to the vacuum at the top part of the condenser where the exhaust steam from the turbine enters. In practice temperature drops of the order of 10 per cent. were until recently in general use, the figure varying, naturally, with the condenser design and the nature of the steam load carried. It was, of course, fully appreciated that such a temperature drop was directly reflected in the amount of fuel used. The loss which is occasioned by a 10 per cent. temperature drop through a condenser can be stated to be about 1 per cent. of the cost of the fuel burned.

An Experimental Regenerative Condenser.

With the object of investigating condenser performance in general, and particularly those factors which control efficient working, G. and J. Weir, Ltd., of Cathcart, Glasgow, caused to be constructed an inverted surface condenser, with a two-pass cooling water arrangement, the air being extracted from the top of the condenser. The steam entered at the bottom of the condenser, and after passing through the first bank of tubes with second pass cooling water, it rose to the second or top bank of tubes, which were cooled with the first pass water as it entered the condenser. By actual observation it was shown that in such a condenser the condensate could be withdrawn at about the temperature of the entering steam, while it could be extracted at all loads at the vacuum temperature with varying amounts of air leakage. It was also found that the tube surface which operated as an air cooler was self-adjusting, so that if a large air leakage took place a greater portion of the surface at the top of the condenser served as an air cooling medium, while with a small leakage only a small portion of the tube surface cooled the air. With such an arrangement, therefore, a maximum tube surface was available for condensing the entering steam, no matter what the amount of air leakage. Furthermore, the cooling of the air was efficiently performed, as was demonstrated by the increasing difference between the vacuum temperature and the air outlet temperature with larger leakages of air. As the condensate was extracted at a temperature corresponding to that of the vacuum, practically no air remained in solution, so that the water was non-corrosive and in excellent condition for boiler feed purposes.

The inverted condenser, which was constructed for experimental purposes, was obviously unsuited in many ways for industrial work, but the essential principles established may be readily applied in a condenser of the type illustrated diagrammatically in Fig. 2. The condenser shown is underslung and it occupies about the normal space of an ordinary condenser. The tubes are arranged in two banks, B being those cooled by the second pass of water and A those cooled by the first pass of cooling water. The steam entering the condenser has a clear passage C which extends right to the bottom of the condenser. A baffle plate D is arranged so that a final ascending flow of air and vapour to the top portion of the first pass tubes A is given. The connection E to the air pump is made at the side of the condenser, while the condensate suction branch F is placed at the bottom of the condenser.

Such an arrangement gives, it is claimed, a complete regenerative effect at all loads. The exhaust steam penetrates to the bottom of the condenser, and so re-heats the cooler condensate which rains down from the tube nests in the upper part of the condenser. As the last portion of the steam flow takes place in an ascending direction, the surface which acts as an air-cooling medium is self-adjusting, and gives a maximum tube surface for steam condensation with all values of air leakage.

The Lister Drive Installation.

A noteworthy example of this new type of regenerative condenser is that which was recently installed by G. and J. Weir, Ltd., in the Lister Drive power station of the Liverpool Corporation Electricity Department, which extension of plant was officially opened at the end of July last. The complete new turbine house equipment comprises a 25,000-kilowatt turbo-alternator by the Metropolitan-Vickers Electrical Company, Ltd., which is designed to supply three-phase, 50-period, 6600-volt current, when running at a normal speed of 1500 revolutions per minute. Steam is supplied at the turbine stop valve at a total temperature of 675 deg. Fah. and a gauge pressure of 275 lb. per square inch. We give a general view of the whole plant on page 500. It shows the turbo-alternator with the condenser, the circulating and extraction pumps and low-pressure evaporator. Fig. 1 shows an elevation and a plan of the installation, whilst in Fig. 3 we give a sectional drawing of the regenerative condenser. The condenser has a steam duty of 260,000 lb. per hour, and is designed for two passes of circulating water through 10,520 solid drawn brass tubes, ¾in. external diameter, 18 w.g. thick, and 20ft. long, giving a total cooling surface of 40,480 square feet. The tubes, which were supplied by the Yorkshire Copper Works, Ltd., are made of "Bemal" metal, and are secured to the tube plates at each end by means of screwed brass ferrules and packing. The ferrules are made in the usual way, so as to prevent undue endwise movement of the tubes, but to allow expansion. A total quantity of cooling water of 23,200 gallons per minute, at an inlet temperature of 83 deg. Fah.,

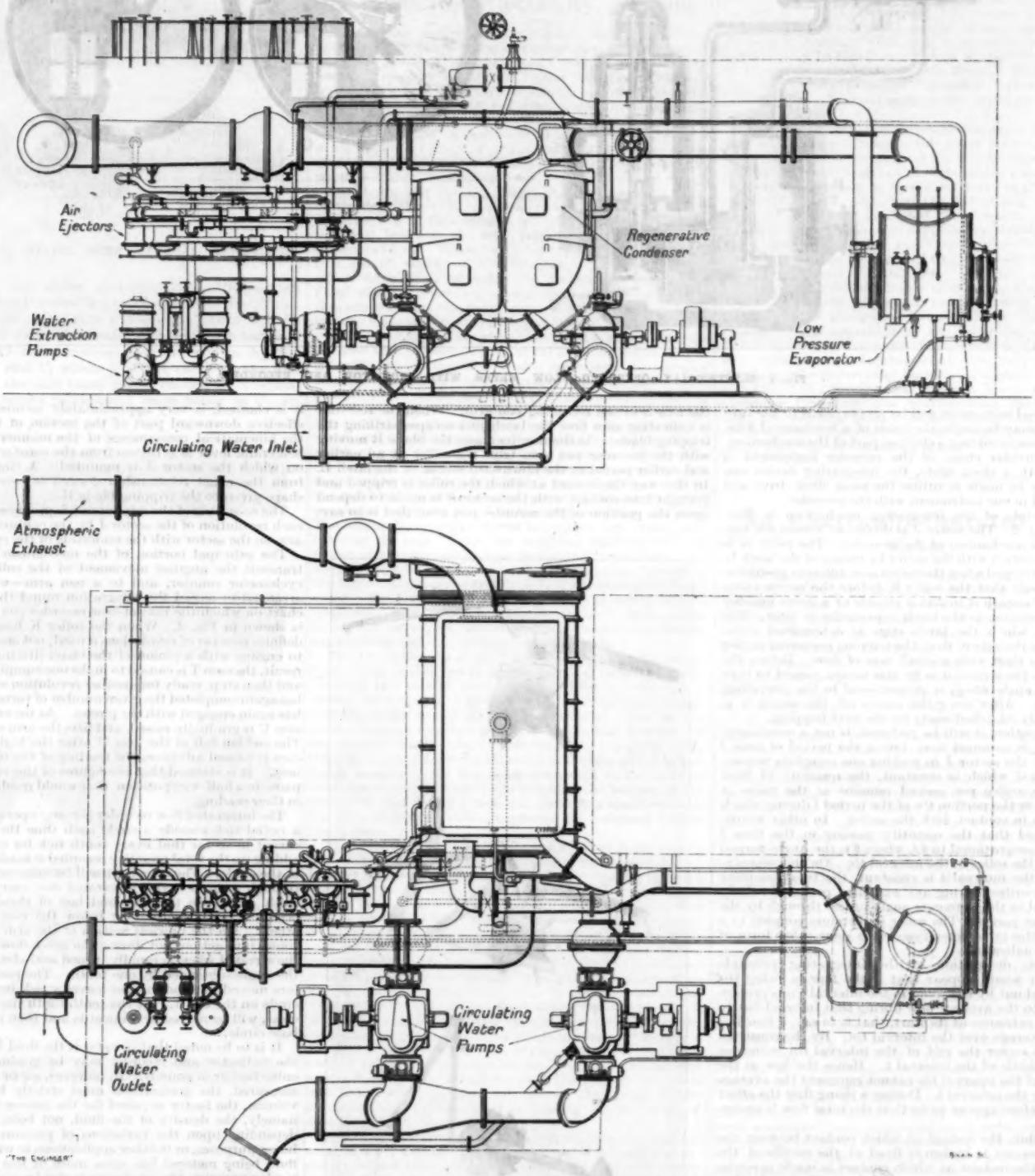


FIG. 1—GENERAL ARRANGEMENT OF WEIR REGENERATIVE SURFACE CONDENSING PLANT

is circulated through the tubes, and is delivered against a head in the condenser of 18ft.

The steam space in the condenser is designed in such a way that the condensate temperature is guaranteed under

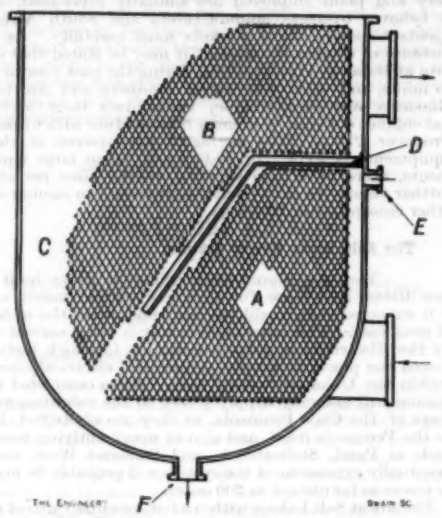


FIG. 2—DIAGRAM OF REGENERATIVE CONDENSER

all variations in load to be within 2 deg. Fah. of the temperature corresponding to the vacuum at the turbine exhaust.

Weir steam-jet air ejectors, with a further third set which is used as a stand-by. Each set consists of one two-stage ejector fitted with an inter-cooler and an after-cooler. The two working sets of ejectors are designed to maintain a vacuum of 27·5in. (barometer 30in.) when dealing with 200 lb. of air per hour, saturated with water vapour and at a temperature of 88 deg. Fah.

The discharge from the water extraction pump passes through both of the ejector surface coolers, so that the whole of the heat in the operating steam is absorbed by the condensate and passes into the feed water, which by stage bleeding is further raised to a temperature of about 150 deg. Fah. before delivery to the feed pump suction. A closed-feed system is used, with a surge tank to meet any load variations. The steam nozzles of the ejectors are made of Monel metal, which has been chosen as being particularly resistant to the cutting action of high-velocity steam, while it is also immune from corrosion. The two sets of ejectors operate with steam at a pressure of 190 lb. per square inch absolute, superheated to a temperature of 675 deg. Fah.

Condensate and Circulating Pumps.

The condensate extraction pumps, like the circulating pumps, were supplied by Drysdale and Co., Ltd., of Yoker, Glasgow, an associated firm of G. and J. Weir, Ltd. There are two vertical electrically-driven pumps, each capable of withdrawing the normal full load quantity of condensate. The pumps are also required to discharge against a static head of 79ft. plus the usual pipe friction. Both of the extraction pumps are arranged so as to be interchangeable for either alternating-current or direct-current drive. They are of the divided casing type, with the suction and the discharge branches on the back half of the pump, thus permitting all the working parts to be dismantled for inspection without having to break any joints. The minimum speed of the direct-current pump is such that there is no possibility of it blowing back owing

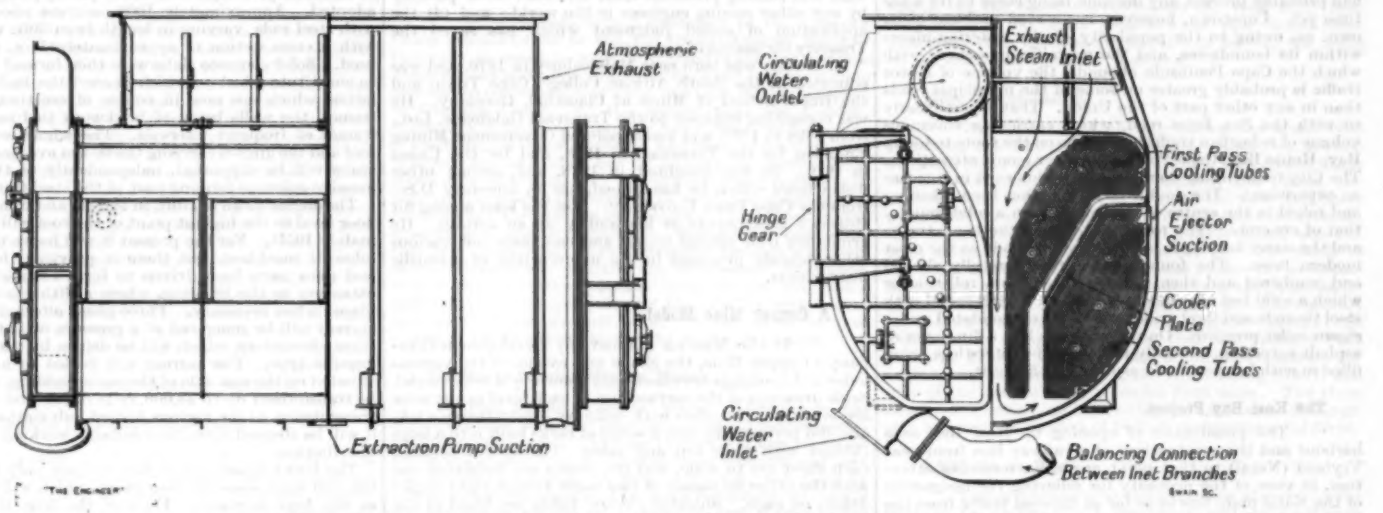


FIG. 3—REGENERATIVE CONDENSER DESIGNED FOR A STEAM DUTY OF 260,000 LB. PER HOUR

The condenser is also designed to be capable of maintaining a vacuum of 27·5in. (barometer 30in.) at the turbine exhaust flange, when 15 per cent. of the tube surface is not in use and when dealing with full steam duty of the turbine. The usual temperature of the cooling water is 83 deg. Fah.

The shell of the condenser is built up of mild steel plates, while the water heads and hinged doors are made in cast iron. The whole weight of the condenser is supported on heavy steel springs, which take up any expansion. It will be seen from our engravings that the end covers of the condenser are made in the form of two hinged doors, which may be removed without having to disturb any pipe joints.

Air Pumps.

The air from the condenser is extracted by two sets of

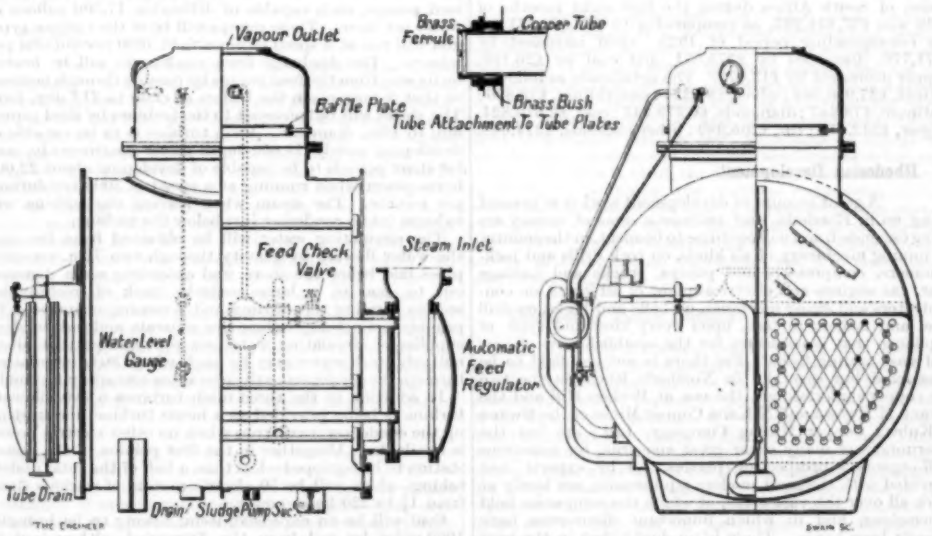


FIG. 4—LOW-PRESSURE EVAPORATOR

to insufficient speed, with consequent inability to pump against the suction effort which is required to overcome the vacuum in the condenser. Variation in pumping capacity can be obtained by the combined or independent running of the alternating-current and direct-current extraction pumps, and for this purpose non-return valves are fitted on each of the pump discharge branches. The pressure stage is vertically above the suction stage, so that it is impossible for air leakage to occur under any condition of working. The pump shaft passes through a free space which is in direct connection with the delivery side of the pump, and is thus completely water sealed. A thrust bearing is provided on the motor end shield, which is designed to carry the weight of the rotating parts.

Two "Drysdale" electrically driven centrifugal circulating pumps, which are to be seen in the foreground of our illustration on page 500, are used for supplying the necessary 23,200 gallons per hour of cooling water for the main condenser. These pumps also handle an additional 600 gallons per minute which is required for the oil and air surface coolers, thus giving a total designed output of 23,800 gallons per minute delivered against a total head of 48ft. One of these pumps is driven by an alternating-current motor and the other by a direct-current motor. The two pumps are made of the opposite hand, but the impellers and shafts of each pump are interchangeable. The alternating-current pump runs at a constant speed of 730 revolutions per minute. A reduction in the flow of water through the condenser may be obtained by reducing the speed of the direct-current motor-driven pump, which may be varied from 620 to 730 revolutions per minute. A very large and efficient working range can thus be obtained.

The Low-pressure Evaporator.

The illustration given in Fig. 4 shows a sectional drawing of the low-pressure evaporator for producing pure boiler feed water. The evaporator will be seen to the right of the illustration given on page 500. It is designed to evaporate 13,300 lb. of make-up water per hour. The working steam is bled from the main turbine at a pressure of 5 lb. per square inch absolute, and the vapour, after passing through the evaporator tubes, is discharged direct into the main condenser at a pressure of about 1·23 lb. per square inch absolute.

The evaporator has a cast iron body with doors of the same material, which are lagged with non-conducting material and are further covered with planished sheet steel cleating. An automatic feed regulator is fitted to maintain a constant water level in the evaporator.

The heating surface of the evaporator, as shown by the drawing Fig. 4, is composed of solid-drawn copper tubes, giving a total of 840 square feet. The tubes are straight and they are attached to the tube plates by means of special brazing metal washers and ferrules, which expose the full bore inlet of the tubes to the steam. The tube fastenings are so arranged that each tube can be removed

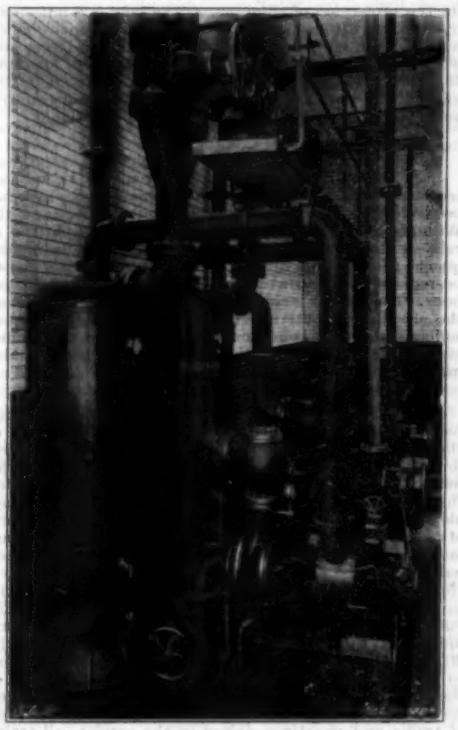


FIG. 5—BOILER FEED PUMPS

separately for cleaning when desired. It will be noted that provision is made to remove any sludge from the evaporator by a special sludge pump which is connected

to the bottom of the evaporator shell. The vapour from the evaporator passes to the condenser and augments the condensate. Condensed heating steam is also added.

BOILER FEED PUMPS.

The feed water which leaves the evaporator is supplied to the feed pump at about boiling point. There are four feed pumps, two of which are motor driven and two of the steam turbine driven type. Only the two latter, however, were supplied by G. and J. Weir, Ltd. They are shown in the illustration of the pump room which we reproduce in Fig. 5. Each pump has a designed capacity of 27,000 gallons of feed water per hour and is fitted with a surface type heater on the discharge side of the pump so that the heat of the exhaust steam from the turbine which drives the pump is utilised to heat up the feed water.

The regenerative surface condensing plant which we have described was supplied to, and its installation carried out to the specifications, of Mr. Harold Dickinson, the City Electrical Engineer of Liverpool.

South African Engineering Notes.

Concrete Roads.

With the spread of motoring and the use of steam and motor lorries for the conveyance of goods, it is becoming recognised that the type of road usual throughout South Africa, excepting within the areas of a few of the largest centres, is quite unable to stand this type of traffic and that the surfaces are being so rapidly destroyed that constant repairing is necessary. There is at present under consideration a scheme of national roads, in the construction of which all the Provincial Councils would share; but the great expense which has to be faced and the impossibility of further increasing taxation at present will probably prevent any decision being come to for some time yet. Capetown, however, has a road problem of its own, as, owing to the popularity of the watering-places within its boundaries, and the magnificent scenery with which the Cape Peninsula abounds, the volume of motor traffic is probably greater on some of the municipal roads than in any other part of the Union. That is particularly so with the Sea Point-road, which carries an enormous volume of suburban traffic and is also on the route to Camp Bay, Houts Bay, Cape Point, and other scenic attractions. The City Council has therefore taken this road in hand as an experiment. The double tram track has been taken up and relaid in the centre of the roadway on a solid foundation of concrete. The roadway between the tram tracks and the street kerbing is being entirely remade on the most modern lines. The foundation is first carefully shaped and cambered and then rolled with a steam roller, after which a solid bed of concrete 6in. thick, strengthened with steel tie-rods and steel grille, is laid and consolidated under steam roller pressure. On top of this is laid a 2in. layer of asphalt carpeting, carefully rolled in, the interstices being filled in with hot powdered asphalt and fine grit.

The Kosi Bay Project.

The possibilities of opening up Kosi Bay as a harbour and the construction of a railway line from near Vryheid (Natal) to that point are again receiving attention, in view of the necessity for relieving the congestion of the Natal main line in so far as the coal traffic from the Vryheid district to the coast is concerned, while it is held that the cost of freight on export coal from the district would be reduced. Kosi Lake is only separated from the open sea on the north coast of Natal and on the border of Swaziland by a sand dune about 300 yards wide and 40ft. high, and the distance between deep water in the lake and deep water at sea is very short. The erection of a breakwater about 1750ft. long would provide an ideal harbour for the protection of shipping, as the lake is 6 miles long by 5 miles wide and has an area of over two square miles, with a depth of over 50ft., while a very much larger area would accommodate vessels drawing from 18ft. to 30ft. It is estimated that the proposed railway would be 163 miles long, would traverse comparatively flat country, and that the maximum gradient would be 1 in 300.

Splitting of Railway Rails.

According to information from Natal, on two sections of the portion of the Natal main line which has been electrified—the Harts Hill-Pieters section and the Willowford-New Black Hill section—serious splitting of rails on the permanent way has developed, and in consequence the speed of running over the sections has had to be reduced from an average of 25 miles to 10 miles per hour. The trouble is said to be due to the side thrust from the electric locomotives. Comparatively new rails have suffered, the split being low down. The affected stretch of line is from 15 to 20 miles, and it is feared the trouble may occur on other sections.

LATER.

Further information with regard to the defects which have developed in the rails on the electrified portion of the Natal Main Line, is to the effect that rails were first found in a bad state along a big stretch of line near Kettlefontein, the wide flange having cracked. It is stated that one hundred rails between Estcourt and Formosa alone are cracked and must be replaced, and consignments of rails are arriving daily. The rails are said to be American, and though cheaper than the British, it looks as if they will eventually prove more costly by their deficiencies. Railway officials consulted, however, consider that the cause of the damage is not the inferior quality of the rails, but that with the extra power provided by the electric units, heavy trains are drawn at high speed along the 3ft. 6in. track, which is not wide enough at the curves to withstand the stresses. Pending the replacement of the defective rails, all trains are being run at greatly reduced speed, a fact which is responsible for much dislocation of traffic and vexatious delays in the service, all trains being behind schedule time.

American Locomotives.

Three steamers arrived at Cape Town docks during the week ended October 2nd from America, carrying between them the parts of 39 heavy-type locomotives for the Railway Administration. A shipment, typical of all three, was that brought by the steamer West Cawthon, from which the heavy lifts to be landed were as follows:—Thirteen boilers, of 35 tons each; 13 under frames, of 30 tons each; 13 tanks, of 19 tons; and 13 frames, of 16 tons. Each of these lifts was greater than any crane in the equipment of the docks could deal with, but a 20-ton crane was borrowed from the engineers engaged on the dock extension works, and the smaller lifts were then managed. The 13 lifts, each of 35 tons and 13 each of 30 tons, or 845 tons in all, were too heavy and must be taken round to East London, landed there, and then hauled round to the Salt River railway workshops, just outside Cape Town, to be assembled. There are further locomotives and wagons, also other railway material, to come from the United States, and the manner with which that country is cutting out British manufacturers is a matter for serious attention. The United States have gained the position of the second most important exporter to South Africa. Last year the value of the imports from Great Britain were £31,119,418. The United States followed with £9,414,084, and Germany came next with only £3,292,491. This year it is expected that the value of imports from the United States will be close to £14,000,000, and may exceed that amount, with a corresponding reduction in imports from Great Britain.

Union Mining Engineer Resigns.

Sir Robert Kotze, the mining engineer to the Government of the Union of South Africa, retired from the position at the end of October. Few South African engineers have had such a distinguished career as has Sir Robert. His more notable achievements include:—(*a*) A decrease of 50 per cent. in mining accidents during his term of office; (*b*) the invention of an apparatus which is being used all over the world, and has greatly helped to reduce miners' phthisis; (*c*) solution of a wider range of financial, legal and mining problems than has been faced possibly by any other mining engineer in the world; and (*d*) the application of sound judgment which has saved the Treasury thousands of pounds.

Sir Robert was born near Malmesbury in 1870, and was educated at the South African College, Cape Town, and the Royal School of Mines at Clausthal, Germany. He was consulting engineer to the Transvaal Goldfields, Ltd., from 1896 to 1907, and was appointed Government Mining Engineer for the Transvaal in 1908, and for the Union in 1910. He was knighted in 1918, and, among other distinctions which he has gained, are an honorary D.Sc. from the Cape Town University. Not the least among Sir Robert's attainments is his ability as an artisan. He grinds his own optical lenses, and can carry out various other delicate processes in the manufacture of scientific instruments.

A Copper Mine Model.

At the Messina (Transvaal) Development Company's Copper Mine, the shape and extent of the various lodes and workings are excellently shown by a mine model. Scale drawings of the surface and of each level in the mine are made on plate-glass with ordinary draughtsman's ink, and slid horizontally into a series of racks built into a large cabinet with glass top and sides. The spaces between each sheet are to scale, and the sheets are registered one with the other by means of two main axes at right angles drawn on each. Shielded electric lights are fitted in the bottom of the cabinet. The result is that the observer looking down into the cabinet through the glass top sees the whole of the mine workings as it were in phantom, and can readily trace the various lodes, exploratory drives, and so forth. The Messina Main Mine model now contains plans down to the 2000ft. level, and as the main shaft is 300ft. lower, and the station for the twenty-second level is cut, that level will be slid into place at the bottom of the series at an early date.

Mineral Production.

The total value of the minerals produced in the Union of South Africa during the first eight months of 1926 was £37,834,222, as compared with £36,052,671 for the corresponding period of 1925. Gold increased by £771,776, diamonds by £975,551, and coal by £26,169. Copper decreased by £13,072. The details are as follows:—Gold, £27,990,568; silver, £88,224; osmiridium, £75,890; platinum, £18,247; diamonds, £6,279,241; coal, £2,619,824; copper, £342,150; tin, £205,380; other minerals, £214,698.

Rhodesian Development.

A great amount of development work is at present going on in Rhodesia, and enormous sums of money are being expended, and will continue to be spent, in the country on mining machinery of all kinds, on rock drills and jack-hammers, compressors and pumps, trucks and haulage gear, gas engines and electrical plant of all kinds, on concentrators and sizing machines, on belts and hoses, on drill steel and lathes; in fact, upon every kind and type of appliance that is necessary for the establishment of new and vast mining fields. For there is not one field to be considered but several. In Northern Rhodesia the two big copper undertakings, the one at Broken Hill and the Bwana M'Kubwa and N'Kana Copper Mines of the Bwana M'Kubwa Copper Mining Company, Ltd., are but the forerunners of many other great concerns, for numerous well-organised prospecting parties, led by experts and provided with the most modern equipments, are busily at work all over the vast areas, of which the companies hold concessions, and in which important discoveries have already been made. There is no doubt that in the near future Northern Rhodesia is destined to become one of the most important of base metal-producing countries. In Southern Rhodesia also large development is taking place, and the recent discovery that the gold reefs there generally improve in grade with depth has resulted in a number of payable propositions being located, and has stimulated prospecting. A tremendous amount of development and constructional work is now in progress all over the country from the Limpopo to the Zambesi and beyond, into the Congo, where the Union Minière is completing plans for making that concern the leading copper producer of the world. The mineral deposits under attack are of a very diversified kind—gold, copper, lead, zinc, vanadium, asbestos and chrome iron ore, besides other metal and mineral products. In consequence the types of machinery and plant employed are similarly diversified, and it behoves overseas manufacturers and South African agents to study these markets most carefully. As an instance of what is being done, it may be stated that one firm at Bulawayo has supplied, during the past year or so, to mines and other concerns in Southern and Northern Rhodesia and Mozambique, twenty-two large suction gas engines of Crossley-Premier manufacture with Crossley Producer Plants. The aggregate horse-power of these equipments is 9174. In addition to these large equipments, there have been supplied, in the same period, a further twenty to thirty small equipments to mining and other enterprises in Rhodesia.

The Salt River Power Station.

The new power house which is being built at Salt River, near Cape Town, is now well advanced, and it is expected that it will be completed about the middle of next year. This large undertaking is being carried out by the Electricity Supply Commission, in which body is vested the power to supply and control electrical energy within the Union of South Africa. When completed the station will not only supply power to the suburban railways of the Cape Peninsula, as they are electrified, but to the Peninsula itself, and also to many outlying towns, such as Paarl, Stellenbosch, and Somerset West, while eventually extensions of the system will probably be made to towns as far distant as 200 miles.

The site at Salt Lake is within a few hundred yards of the sea, from which about one million gallons per hour will be drawn for circulation through the condensers. The cost of land is low, and it is situated at about the electrical centre of gravity of the system.

To provide suitable foundations for the large masses of machinery, boilers and other plant, piling had to be adopted. Approximately 1000 concrete piles, reinforced with steel rods, varying in length from 30ft. to 40ft., and with a cross-section of approximately 14in. square were used. Solid concrete slabs were then formed on the piles to constitute a bed on which to erect the buildings. The latter, which are now in course of erection, have steel frames, the walls being of brickwork tied into the steel frames at frequent intervals. The whole weight of the roof and the girders carrying the 60-ton overhead travelling crane will be supported, independently of the walls, on massive columns forming part of the steel frame.

The engine-room is 170ft. in length, and from the ground floor level to the highest point of the roof will be approximately 105ft. For the present it will house three 10,000-kilowatt machines, but there is provision for a fourth, and piles have been driven to form foundations for an extension to the building, where a fifth machine can be placed when necessary. Three-phase alternating 50-cycle current will be generated at a pressure of 12,000 volts by three alternators, which will be driven by turbines of the impulse type. The current will be led to a sub-station situated on the east side of the main building, where it will be transformed up to 33,000 volts in the first instance for transmission to the various distant sub-stations, at which it will be stepped down to a suitable working pressure for distribution.

The boiler-house will at first contain only four boilers, but will have space for four more, which will be installed as the load increases. Each of the four Babcock and Wilcox boilers will have an evaporative capacity of 60,000 lb. of water per hour, and will supply steam at a pressure of 250 lb. per square inch and a temperature of 700 deg. Fah. These boilers will be mechanically fired, the coal passing down from overhead bunkers. The combustion air will be passed through heaters, where its temperature will be raised to between 300 deg. and 400 deg. Fah., by means of the waste gases, and, in addition to the forced draught fans necessary to drive this air through the heaters and the grates, there will be fans for inducing a draught in the chimney. These fans, of which there will be one set to each boiler, will be installed on the roof of the boiler-house. The boilers will each be fed by three feed pumps, each capable of delivering 17,500 gallons of water per hour. These pumps will be of the turbine type, and will run at a speed of more than 7000 revolutions per minute. The discharge from condensers will be heated on its way from the feed pumps by passing through heaters, so that it may reach the boilers at close to 212 deg. Fah. The steam will be conveyed to the turbines by steel piping 8in. to 12in. diameter. Each turbine is to be capable of developing nearly 14,000 horse-power continuously, and for short periods to be capable of developing about 22,000 horse-power when running at a speed of 3000 revolutions per minute. The steam when leaving the turbine will exhaust into a condenser just below the turbine.

The circulating water will be obtained from the sea, the water flowing by gravity through two 72in. concrete pipes laid below the shore, and extending some distance out to sea, to a large concrete tank of rectangular section forming the settling and screening chamber. To provide against any failure two separate and independent supplies of circulating water are provided so that alternatively fresh water may be used, which after circulating through the condensers will go to a concrete spraying pond.

In addition to the three main turbines a 300-kilowatt turbine is being provided as a house turbine, for starting up the condenser auxiliaries when no other electric power is available. Altogether in the first portion of the power station to be equipped—less than a half of the total undertaking—there will be 50 electric motors of various sizes, from 1½ to 220 horse-power.

Coal will be an expensive item, having to be brought 1000 miles by rail from the Transvaal, although it is possible that Natal coal, brought round by steamer from Durban, may be found cheaper. On arrival at the power station there are several sidings for the coal trucks, from which they will pass over a coal weighing machine on to the coal hopper, from which it will be taken by a rubber belt conveyor to a junction tower about 15ft. high, from which it will be carried on another belt in the same direction, gradually ascending until it reaches the top of the boiler-house, where it will be "tripped" into any desired bunker. Alternatively, at the junction tower it may be transported along another branch to a storage yard by

means of a third conveyer belt, which is to be reversible, so that coal may also be taken from the store to the bunkers.

The whole of the equipment of the power station is being supplied by British firms, the English Electric Company, Ltd., having by far the biggest share. The coal strike in England has affected the progress of the work to a small extent, owing to the inability to execute the contract for steel sections within the stipulated period, but apart from that slight hitch, the amount of work completed and the future prospects are highly satisfactory in every respect.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

General Conditions.

THE industrial situation in the Midlands and Staffordshire has changed little, if any, during the past week. The iron and steel furnaces and mills remain idle, but engineering works are carrying on in a fitful manner, working up to the full capacity of the raw materials available. The scarcity of iron and steel remains the main deterrent to business, and until the home mills and furnaces can be got going again the position is not likely to show any change for the better. Continental supplies are, if anything, more difficult to obtain, and prices have again increased, but unless engineering firms are prepared to close down altogether they must avail themselves of what material they can get, whether native or foreign, and at whatever price the seller cares to ask. It is no easier to get fuel than it was a month ago, but the failure of the raw material supply is a much more acute difficulty than that of fuelling. There is now very little unsold material in sight, delivery of which can be expected before the New Year and business is now being done for January and February. Exhaustive inquiries are being made for any odd lots of steel available, but the responses are inadequate. Local heavy edge tool works have been forced to suspend large numbers of employees, and those still on the pay roll are only working one or two days per week. Motor engineers with large orders are restricted in their output through the lack of forgings, and builders of rolling stock are on short time through steel scarcity. The manufacture of structural steel work is carried on under great difficulties, and it is feared that operations on many building structures will shortly have to be suspended. Everywhere in the Midlands the reports are the same—"Plenty of work; no steel; no iron." The position is undoubtedly getting desperate and unless some good results accrue from the conferences now taking place with the object of settling the coal war the industries in this part of the country will be brought to a complete standstill.

Heavy Demand for Future Production.

The present unsatisfactory industrial position is the more galling because from the point of view of demand the outlook in the iron and steel trade is bright. Large business is pending. The extensive booking of motor cars and the great activity at the works indicate a very heavy demand for steel, especially of the higher qualities. Engineers are tendering constantly for all sorts of structures, while the placing of important orders for ships seems to promise a heavy demand from the yards. Rolling stock works in this district have well-filled order books, and it is well known that the home railways will be big customers when they consider the proper moment has arrived to place orders. What is wanted, and what we must have, is coal in abundance and at moderate prices to enable the mills and furnaces to get to work again. Many industrialists here predict a mild boom in iron and steel once normal production is resumed.

Pig Iron.

The pig iron famine daily becomes more acute. Occasionally a moderate tonnage can be got from France, but such supplies are spasmodic and generally unreliable. The position has been aggravated by slow deliveries, and prices are advanced to cover the increase in freights following the large absorption of shipping for coal conveyance. The foundries in Birmingham and the district have plenty of work on hand, and to an increasing extent they are having to depend for their pig iron on the continental makers. Luxembourg pig iron at to-day's market ranged from £5 5s. to £5 10s. delivered. A superior grade of Swedish foundry iron was sold at from £6 5s. to £6 15s., according to size of order and length of haul. For the small tonnages of native pig which are obtainable, increased prices have to be paid. For No. 3 Cleveland foundry iron £6 15s delivered Birmingham is required. Durham foundry material has advanced a further 1s. 3d. per ton, making No. 1 £6 7s. 6d. and No. 3 £6 2s. 6d. delivered. The foundries for the most part manage to keep going, but they are working from hand to mouth and in fear of stoppage.

Steel.

The steel scarcity has been heightened by delays in delivery of continental material. Supplies have contracted, and this fact has combined with transport difficulties to make the situation of consumers in the Midlands more harassing. Some foreign steel plates received this week are stated to have been awaiting export at Antwerp since the middle of August. Prices of continental material continue to rise, but large quantities are being bought, and it is just possible that the end of the strike may find buyers hampered with contracts likely to prove unprofitable. For continental billets importers want upwards of £6 10s.; plates, £7 12s. 6d.; bars, £7 2s. 6d.; joists, £7; Belgian No. 3 bar iron, £6 17s. 6d.—all per ton delivered. Staffordshire re-rollers still quote £8 15s. for small bars and about the same for angles. As much as £11 is asked for steel strip.

Staffordshire Iron.

Makers of finished iron in Staffordshire have plenty of orders, but the production of wrought iron at present prices of fuel would involve considerable loss. Some of the orders in hand have been on the books since May, and were taken at pre-strike prices. There are a few forges at work in the Black Country producing wrought iron, for which eager consumers are ready to pay substantial additions to the selling price to cover the extra cost of coal. In some cases as much as £15 per ton has been paid. One mill is meeting a demand for best iron by rolling down old engine shafting, and the same material is being utilised for the production of forgings by the manufacturers of edge tools. The country is being scoured for everything usable.

Galvanised Sheets.

Galvanised sheets continue in good demand. The home trade is quiet, but inquiries from overseas markets have resulted in more business. Exceptional prices have been accepted for specially desirable orders, but district mills generally quote £17 5s. to £17 10s. Tin-plates are again dearer. Mills are very hard put to it to maintain the recent rate of production.

Fuel.

Midland manufacturers find the fuel position most difficult. The price of slack, for which the demand is insistent, has advanced considerably, and works coal quotations are no easier. Output from some of the Midland pits has increased considerably, but the major portion of it is absorbed by the domestic user. A fair amount of buying on behalf of Scottish merchants is this week reported.

New Railway for Cannock Chase.

Great satisfaction is expressed in the Cannock Chase coalfield that at last the Great Western Railway Company proposes to meet a long-felt want and provide much needed additional transport facilities for this mining area by the construction of a new line from Wolverhampton to Cannock Chase. At the present time the London, Midland and Scottish Company has a complete monopoly of the Cannock Chase coalfields, and the coal for the Great Western Railway lines has to be sent to Wednesbury, where it is often held up. The proposed new railway will remove the monopoly referred to and give much better facilities for the sending of Cannock Chase coal to the western and southern markets. The work of surveying the area stretching from Brereton, through Cannock Wood, Hednesford, Huntington, Hatherton, Shareshill, Hilton and Wolverhampton, is being carried out, and a draft of the proposed route of the new railway has, I understand, been decided upon. A Bill is to be promoted in Parliament to secure the necessary powers.

University Scholarships for Miners.

The Miners' Central Welfare Committee has decided to offer next year ten scholarships to enable miners to enter a university. They are to receive a sum for outfit which will enable them to dress as other students and they will live in the college, so that in no way will they be different from the others. Viscount Chelmsford, who made the announcement in an address to the Warwickshire county mining students at Nuneaton on Saturday last, explained that the recipients of the scholarships need not continue in the mining trade. They would be guided by the Election Committee as to the best career, whether medicine, art, literature, or any other subject. Lord Chelmsford, who is chairman of the Miners' Central Welfare Fund, added that the Committee proposed spending in four years a sum of £4,000,000 on pit-head baths for miners, and four experimental baths were first to be set up in Scotland, Durham, Warwickshire and South Wales.

Colouring Stainless Steel.

Midland engineers have this week carefully weighed the claim of a well-known Birmingham woman engineer to have discovered a process for colouring stainless steel. They are pretty generally agreed that the discovery should find entirely new markets for this material in the way of decorations, such as shoe buckles, name plates, switchboards, hat and dress ornaments, household furnishings, and, in fact, thousands of things for which gold and silver and commercial enamel have hitherto been used. Miss C. Griff, the discoverer, who is well known in Midland mechanical and electrical engineering circles, states that the secret lies chiefly in preparing that part of the surface which is to be coloured and in protecting that part which is not. Negotiations for establishing the discovery as a commercial proposition are, it is understood, practically completed.

Engineering Trades Outlook.

The epoch-making report issued this week on the condition of the engineering industry, prepared by Mr. D. A. Bremner, director of the British Engineers' Association, at the request of the Preparatory Committee of the Economic Conference of the League of Nations, was much discussed on 'Change in Birmingham to-day (Thursday). Attention was particularly directed to his statement that a serious weakness of the British engineering industry lies in its defective organisation for the purposes of the representation, promotion and defence of its interests at home and abroad, and for participation in international negotiations, which promise to be of considerable importance in the future. The disparity, Mr. Bremner states, between potential production and actual consumption is so great that it is causing grave anxiety to leaders of industry in the principal manufacturing countries, more especially in Europe, and unless the problem is solved a large amount of machinery and plant will have to be thrown out of action and written off. He closes by declaring that whatever speculations may be indulged in about the distant future, the fact to be faced now is that there is no way of substantially increasing the world consumption of the products of engineering industry without cheapening them.

The Notts. Miners' Breakaway.

Representatives of Notts. miners, at a meeting on Monday night, decided in favour of a district settlement, and a deputation was appointed to meet the owners on Wednesday for the purpose of ending the dispute by a local agreement. Owing to the inability of the owners, however, to meet in time for a discussion among themselves, the joint conference has been postponed until next week. This delay, it is pointed out, does not involve any abrogation of the acceptance of district terms upon the part of the bulk of the Nottinghamshire miners.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

Textile Mills and the Factories Bill.

TEXTILE mill interests view with uneasiness the power conferred upon the Home Secretary under the new Factories Bill, which has been the subject of a report by a joint committee of the Trade and Law Committees of the Oldham Chamber of Commerce. As an example of the way in which some of the clauses, it is feared, will interfere with productive operations, it is pointed out that it is required under one clause that cards shall be ground three times in four weeks, that is, eighty-four cards a week. This operation entails the running of the machine in the reverse direction, which is done by taking off the strap and putting on a cross strap in place of an open one, or, *vice versâ*, entailing a change of eighty-four straps each way, or 168 changes a week. Arrangements, it is said, can be made to prevent the straps resting on the revolving shafts, but the committee expresses the view that these methods are extremely cumbersome and much more dangerous than the present practice of leaving the strap on the shaft and tying or "hatching" it.

More About Cables.

The question of electric cables has again been exercising the Salford City Council, which, on several occasions this year, has placed contracts with Dutch firms. On this occasion, however, the Council has placed the contract with a local firm in spite of the fact that there was a difference of £562 in favour of the Dutch firm's tender, this being £1835, compared with £2397, which was the price submitted by the local concern for 7000 yards of low-tension cable. This decision was in face of the recommendation of the Electricity Committeee that the tender of the Dutch firm should be accepted. A cable contract for Salford was placed in Holland early last month, the Dutch tender being £1062, whilst that of a Trafford Park firm was £1248. In March last a previous contract for cable was placed in Holland, the figure being £1497, and that of the nearest British tender £405 more. The three examples illustrate an interesting fluctuation in the margins between the tenders of British and continental firms.

Additions to Work.

Useful additions to the contracts already on the books of Lancashire textile machinists and electrical engineering firms have been announced this week. Platt Brothers and Co., Ltd., of Oldham, have secured the contract for the installation of the machinery at the New Elk Mill, Royton, consisting of 42 pairs of mules, 180 carding engines, and over 100,000 spindles, and also a contract for 70,000 high-draft ring spindles for the new Bury Ring Mill. Platt Brothers are already busily engaged on Russian contracts for textile plant placed some time ago. Another Oldham firm of textile machinists, Asa Lees and Co., Ltd., have just completed the equipment of an extension at the Park (No. 2) Mill, Royton, including 13 sets of card-room machinery and 12 pairs of mules. It is also announced that the Metropolitan-Vickers Electrical Manufacturing Company, Ltd., Trafford Park, has secured the contract for the electrification of 73 kiloms. of the Brazilian West of Minas Railway, between Barra Mansa and Augusto Pestanha.

The General Outlook.

Discussing the outlook in the engineering and allied industries of this area, the October issue of the Manchester Chamber of Commerce *Record* says:—The engineering trade has had many difficulties created by the coal stoppage and the state of other trades. Overseas' contract opportunities have been fairly numerous, but it has not always been a simple matter to accept them, in view of the dislocation of the iron and steel trades and the high cost of coal. Textile machinists are not fully employed, as neither home nor foreign millowners have been able to place many orders under the existing conditions. Heavy electrical engineering is in a better position, although here again there are difficulties. Boilermakers have had insufficient work and machine tool makers have had a dull time. There is a feeling, however, that the industry will do better when the coal trade dispute is settled.

Non-ferrous Metals.

Tin, especially, and also copper, lead and spelter have been easy sections of the non-ferrous metal market during the past week. Steady attacks on the market by "bearish" interests are said to be responsible for the break in tin, which has been little short of sensational, ranging from about £11 to £15 per ton, according to position. The current week opened rather better, and at the time of writing a little of the lost ground has been recovered, although market sentiment has not been improved by the month-end statistics, the visible supply at the end of last month being estimated at about 14,000 tons, or an increase of 584 tons over the end of September. The demand is quiet, and in view of the uncertain position as regards prices, consumers are likely to proceed very cautiously for the time being. In spite of the operations of the Copper Exportation Association, the price of the

metal has suffered a slight decline, although at the moment the feeling is rather steadier. In the meantime the demand is only moderate. There is only a quiet demand also for both spelter and lead, and compared with prices current a week ago, quotations in each case are on a lower level.

Iron.

Fuel prices are a matter of deep concern to both iron and steel makers, and there has been a good deal of discussion here this week as to the future position. Midland iron producers estimate that if they were to pay the current prices for blast furnace coke—between £3 and £3 10s. per ton—the fuel costs alone per ton of pig iron would not be much less than £5 10s. The prices now being demanded for coke are, of course, the result of the prevailing conditions of supply and demand, and will come down with a run as the position approaches normal. What chiefly concerns the iron maker to-day, however, is the point at which the fall will stop. Many of them have substantial quantities on their books that were contracted for before the coal stoppage began at something like £3 7s. 6d. per ton at the furnaces. Since then they have booked fair quantities at about £4 per ton f.o.t., although they ceased quoting altogether towards the end of September. What they are anxious to know now is whether fuel prices will come down sufficiently to allow these contracts to be executed, if not at an economic price, at all events at a price which will not entail a serious loss. There are no supplies of Midland common irons on offer, parcels being still limited to Scottish, Middlesbrough, and some East Coast hematite. The two former for prompt delivery have been quoted this week at about £7 per ton, delivered Manchester or equal distance, although offers are by no means firm, in almost all cases being subject to being unsold. For small lots of hematite about £6 per ton delivered has been asked. Manufactured iron is very scarce, and prices are nominal at £12 per ton for Crown bars, and £10 15s. per ton for second qualities. Practically none is being made, and there seems to be little immediate prospect of a resumption.

Steel.

In the steel market it is extremely difficult at the present time to find anybody who is willing to enter into forward contracts, and prices that are mentioned, although forming a guide, are, to a large extent, nominal. Ship and tank plates have been mentioned at about £8 15s. to £8 17s. 6d. per ton, delivered, with joists and sections at £8 to £8 2s. 6d., basic steel bars at £9 5s. to £9 10s., and boiler-plates at £11 15s. to £12 per ton. It is not surprising, under present conditions, that actual business is virtually at a standstill. Re-rolled bars for delivery in about three weeks are dearer and are now being quoted at £10 to £10 10s. per ton delivered, the higher prices now being asked being due to dearer foreign billets and to increasing fuel difficulties. There is not much being done in imported materials at the moment, and continental steel bars are quoted at about £6 17s. 6d. per ton, delivered Manchester or equal, for cash against shipping documents; Belgian bar iron is quoted at £6 12s. 6d. to £6 15s., sheet bars at £6 10s. to £6 12s. 6d., billets at about £6 5s., joists and sections at £6 17s. 6d., light plates at about £7 10s., and Siemens plates at £7 15s. per ton. British galvanised sheets for the Indian market have been quoted here during the past few days at about £17 per ton f.o.b., but there are not many makers who are now quoting, most of them having withdrawn. A slightly more active inquiry for thin gauged sheets from the Far Eastern outlets has been reported at about £25 10s. per ton for Shanghais, £24 5s. for Bangkoks, £25 2s. 6d. for Rangoons, and £23 5s. for Straits.

Scrap.

There has not been much demand for non-ferrous metal scrap, and prices in some sections are easier in sympathy with the new metals. Selected gun-metal scrap is quoted at about £52, clean light copper at £56 10s., heavy copper at £62, scrap lead at £29 10s., zinc at £25, and selected heavy yellow brass at about £40 per ton, delivered to users' works, for properly graded qualities.

BARROW-IN-FURNESS.

Hematite.

There is no development in this district as regards the production of pig iron, and this state of things will continue to exist until fuel becomes normal both as regards price and delivery. Makers are simply waiting to start on a period which for activity will, it is anticipated, be better than any this district has experienced for several years. They are well fixed for orders and that fact is reflected in the prices which now obtain. Fancy prices have been quoted for pig iron, but they have referred to small parcels held by people other than makers. It would be difficult to find any now. The inquiries are good, and special qualities of iron have received attention from customers who, as soon as it is possible, require deliveries.

Iron Ore.

Very little ore is being raised, and the mines are waiting for the furnaces to be put in blast again, when they will be busier than they have been for some years. Foreign ore is not being imported, but as soon as iron is being produced again, the imports will begin. At present the importation of iron ore would be out of the question in view of the high freights which are ruling.

Steel.

The hoop works continue to work on orders, and their outlook in view of the better cotton trade promised is good. Other steel departments will not start until times are normal again. Fair orders are held, but there is not the same demand for steel as for iron. The stationary prices of steel show that. Coal imports are down as compared with the previous week.

SHEFFIELD.

(From our own Correspondent.)

The Shortage of Steel.

THE difficulty of carrying on the steel trades grows more and more acute, owing to the exhaustion of stocks of material and the impossibility of replenishing them while present conditions continue. There is no more melting of open-hearth steel than the very small quantity that has been reported during the last few weeks. Not only is coal scarce and dear, but pig iron is almost exhausted. An instance of how large firms are hit was seen by the guests of the Master Cutler when they visited the works of Vickers, Ltd., on Friday last week. Only one Siemens-Martin furnace was in commission, instead of the seven or eight of normal times. The steel being produced was for railway purposes. Coal, although still not plentiful, is less scarce than it has been, but owing to the high price its use is not economically possible on a large scale for general purposes.

The Manufacturing Departments.

The branches which need steel for working up are not only short of English supplies, but are finding it difficult to obtain foreign material, and, owing to delays in transport, work is being held up. There is an acute shortage of coke, little or none of which is being made in this country. As a result of the difficulties of executing orders here, foreign business is being diverted to America and the Continent, while arrears of home orders are piling up to a larger extent every week. There is little doubt that, when the strike is over, considerable activity will prevail, for a time at any rate. Some departments, which are not so seriously affected by the dispute, report increased work already. One of them is electrical engineering, which is very busy. The motor trade is also well employed, and is making a good demand for steel. Some of the Sheffield departments which produce drop stampings for motor and aeroplane work have successfully adapted their furnaces to oil fuel, and are continuing to supply the demands of their customers. File manufacturers are unable to obtain supplies of billets, and as a consequence their trade has fallen off to a considerable extent. Severe difficulties also beset the tool-making departments, but some of them are doing fairly well.

Crucible Steel.

The importation of foundry coke of very good quality from Germany has for some time been of very great assistance to the crucible steel makers of the city, enabling them to resume melting and to produce on a considerable scale. They have just received a shock, however, as the result of a serious increase in the price of coke. Originally, the cost was 67s. 6d. per ton delivered. That was high enough, and meant a loss to the crucible steel maker, as he was unable to recoup himself for the increase by adding to his selling quotations. Work was carried on, however, even under those conditions in order to retain business connections. But now there has been a sudden jump in the price of Westphalian coke to 80s. per ton, with the possibility of a further advance, and that has made the cost of crucible steel melting prohibitive, except in special cases. Activities at the furnaces have been greatly reduced, but the larger firms, especially those supplying steel to the motor industry, have consented to buy at the enhanced price, and will continue melting.

New Coal Selling Organisation.

Fuller particulars are now available of the coal selling organisation which was announced at the annual meeting of the United Steel Companies last week. The combine, which is known as the Rotherham and District Collieries Association, Ltd., has been duly registered as a company limited by guarantee, and not having a share capital, with 100 members. The scheme embraces eight collieries, employing a total of about 14,850 men, and having an aggregate output of over 4,000,000 tons per annum. The collieries concerned are:—United Steel Companies; Orgreave, Fence, Treeton and Thurcroft Main; John Brown and Co., Ltd.; Aldwarke Main and Rotherham Main; Dalton Main Collieries; Silverwood and Roundwood. Mr. H. A. Wright, who has for some years been in charge of the Dalton Main Company's coal-selling arrangements, will be the general manager of the new Association, and the office will be at 18, Tree Root-walk, Sheffield.

Indian Railway Needs.

Schemes of railway electrification are afoot in India, which will involve an expenditure of about £5,000,000. One of the lines in which electrification progress is being made is that of the Great Indian Peninsula Railway. The scheme has already brought useful work to Sheffield firms and their associated companies, and tenders are now being invited for further work, including approximately 280 miles of overhead transmission line to be delivered and erected, and track equipment, comprising overhead work and steel structure, for about 140 miles of railway route. The India Store Department is also inviting tenders for wheels and axles complete with spur wheels and pinions, for motor bogies, 384,000 sets of sleeper plates, 1,582,080 cotters, 387,840 tie bars, and 791,040 steel keys for railway rails.

Cutlery and Plate.

The rather brighter reports of the condition of the cutlery and plate trades which I have been able to give during the past few weeks cannot be continued at present. Apart from spasmodic buying, the special season trade appears to be at an end, and, although there is still a certain amount of activity, it will quickly taper off unless the unexpected happens. A number of large orders were booked during recent months, but the majority of them have been completed, and at the moment little or nothing is coming forward to take their places. Overseas business is quiet, as is usual when the shipment of the annual Christmas orders has been completed. At the recent English sales of ivory, prices rose about £5 per cwt., and that increase was maintained at Antwerp. The progress of the Sheffield safety razor blade continues, and a large firm in the city has now definitely embarked upon a campaign to capture the trade in America.

Important Markets Scheme.

During the recent municipal elections in Sheffield an important scheme of markets reconstruction, which is at present receiving the consideration of a special committee of the City Council, was made public. The Corporation owns the market properties, which it purchased from the Duke of Norfolk about a quarter of a century ago for upwards of half a million pounds. Councillor Hunter, who has put forward the scheme, proposes that on the site of two of the present markets large two-storey buildings should be erected, that the first floors should be connected by a bridge, and that there should be an escalator from the ground level to the first floor. These markets would not only provide accommodation for wholesale and retail fruit and vegetables, as at present, but also for the retail meat market, which would be removed from a large hall which it now occupies on one of the most valuable sites in the centre of the city. The estimated cost of the erection of the new buildings is £146,000, but it is expected that twice that amount would be realised by the sale of the site of the meat market. The annual revenue from the new scheme is calculated at £37,000.

Electricity Extensions.

The post-war extensions of the Wakefield Corporation electric power station were opened last week, when Alderman W. Emmett, the chairman of the Electricity Committee, started up the new 7500-kilowatt set. The total capacity of the station is now 15,750 kilowatts, as compared with 3750 at the end of the war. The city electrical engineer, Major H. G. Fraser, and his staff have designed and carried out the whole of the extensions and reconstruction work. In connection with the electricity scheme of the Retford Corporation, the following tenders have been accepted:—Foundations for generating station, condenser and dynamo, the François Cementation Company, Ltd., £799; water tank for water-cooling tower, Messrs. Robert Dempster and Sons, Elland, £250; rolled steel joist supports, Messrs. Dempster and Sons, £62.

A Vickers' Director Retires.

Some surprise has been occasioned in the city and district by the news that Major J. L. Benthall, one of the Sheffield directors of Vickers, Ltd., has retired, his resignation having taken effect on October 31st. Major Benthall has been a well-known figure in local business life. Leaving Harrow at the age of eighteen, he was for seven years in the shipyard of his grandfather, the head of the firm of J. d'A. Samuda Brothers, of Poplar, the great shipbuilders of the Thames. He joined Messrs. Vickers in 1893, and became a director in 1910, having control and supervision of the armour-plate department. He intends to take up other work in the New Year.

NORTH OF ENGLAND.

(From our own Correspondent.)

Iron and Steel Imports and Exports.

WHILE the bulk of the iron and steel works in the Cleveland district remain idle owing to the coal stoppage, the imports of foreign products continue to increase on a large scale. During October the imports of iron and steel into the river Tees totalled 39,011 tons, comprising 19,492 tons of pig iron, 14,670 tons of crude sheet bars, billets, blooms, slabs, &c., and 4849 tons of plates, bars, angles, rails, sheets, joists, &c., as compared with a total of 38,611 tons in September, and 23,987 tons in August. For the twelve months ending October 251,880 tons, comprising 31,602 tons of plates, bars, angles, &c.; 79,502 tons of pig iron; and 140,776 tons of crude sheet bars, billets, blooms, &c., were imported, as against 181,399 tons in the corresponding period of 1924–25, and 54,564 tons in the pre-war period of 1913–14. An increase of over 4000 tons was recorded in the iron and steel exports from the river Tees for October over those of September, the respective totals being 26,955 tons and 22,075 tons. The pig iron shipped last month totalled 3069 tons, as against 3245 tons in the preceding month, Italy being the largest customer with 800 tons, while Belgium received 575 tons and France 542 tons. The manufactured iron and steel exported reached 23,886 tons, of which 7255 tons went to India, 1701 tons to Australia, 1585 tons to Natal, and 1400 tons to Egypt. In September 18,830 tons of manufactured iron and steel were shipped from the river.

Cleveland Iron Trade.

Obstacles to trading continue to increase in the Cleveland pig iron industry, and actual business has probably reached the lowest ebb in history. Commodities in request are only available in very small lots, and while some venturesome traders appear less inclined to abstain from negotiating on forward account, very few actual contracts for delivery ahead are being arranged, as future values cannot be gauged. The figures detailed above reveal the extent to which industries in this district are now relying upon foreign sources of supply, and further shipments of foreign pig iron and semi-steel for re-rolling are due this month; but rapidly rising freights and the difficulty in securing cargo space have confused the situation. It is, in fact, impossible at the moment to buy foreign iron with any hope of reasonable delivery, and it is feared that many more foundries will have to be closed down. Cleveland pig iron prices are now stationary, and it is suggested that they have reached the peak. But whilst this may be so, it need not be too readily assumed that there will be a sudden collapse when the miners decide to resume work. On the contrary, pig iron is likely to be scarce and dear for some time to come, and with this contingency in mind a few buyers have contracted for supplies to the end of the year on the basis of present prices.

No. 1 Cleveland pig iron is 125s.; No. 3 G.M.B., 120s.; No. 4 foundry, 119s.; and No. 4 forge, 118s. 6d. per ton.

Hematite Pig Iron.

East Coast hematite pig iron is very scarce. Ordinary mixed numbers are not available for sale, and only odd parcels of other descriptions are purchasable. Off grades are selling at prices ranging from 87s. 6d. to 90s. per ton.

Ironmaking Materials.

There is a continued complete stagnation in the foreign ore trade. Best Rubio ore is nominal at 21s. 6d. per ton c.i.f. Tees. Consumers of coke experience difficulty in securing adequate supplies, and values are tending upwards. Round about 57s. 6d. per ton is named for foreign descriptions, and home products are quoted considerably above that figure.

Manufactured Iron and Steel.

There is no new feature of moment in the manufactured iron and steel trade. Purchase of foreign materials for use in this district has fallen off, due largely to difficulty in obtaining early delivery, and possibly to some extent to continental producers having again advanced prices. Common iron bars have been advanced this week by 10s. to £11 15s. per ton. Galvanised corrugated sheets, 24-gauge, are firm at £17 5s. per ton.

The Coal Trade.

There is no possible chance of entering into negotiations for the export coal trade, as shippers cannot yet form any idea as to when supplies will be available. The general situation, however, is more favourable than for some time past. At all centres more men are employed, and the output is gradually increasing, but all supplies are ear-marked for domestic and other priority uses, and export supplies are not expected to be available for two or three weeks. Inquiries from the Continent are numerous, and point to a good trade being available whenever supplies can be shipped. The Norwegian order for the State Railways, which has usually been placed in Durham and Northumberland, has gone to Germany, and at a good price. The inquiry was for 40,000 tons of steams for delivery over the first quarter of next year, and Westphalian shippers have secured the contract at about 32s. 6d. per ton f.o.b. Rotterdam. The quotations sent in from this area were lower, but there was no guarantee of delivery, nor could there be in the present uncertain state of things in the United Kingdom. There is reason to believe that German coals have been heavily sold over the first quarter, and up to the end of the first half of next year, and largely among those who used to be customers of Northumberland and Durham. Owing to increased home production, there is a lull in the operations for imported coal. The demand for early delivery shows no signs of slackening but there is a distinctly easier tendency for December and later deliveries. For prompt supplies of American coals prices are quoted higher at 55s. to 65s. per ton c.i.f., but for next month rule round about 55s.

SCOTLAND.

(From our own Correspondent.)

Shipbuilding: Small Output.

The effect of the coal strike and the consequent shortage of materials is simply illustrated by the Clyde shipbuilding returns for October. During that month only four vessels of an aggregate of 12,818 tons were launched, that being the lowest monthly figure for this year to date. The total for the ten months just concluded, amounting to 112 vessels of 256,553 tons aggregate, is the lowest for over twenty years, and compares with 186 vessels of 471,018 tons aggregate for the same period last year. This decrease is almost totally explained by a lack of materials and fuel, as builders have contracts on hand representing a much larger tonnage output, if normal progress could have been made. The output for October was made up of two cargo steamers, one hopper dredger and a motor launch:—Shakespear, cargo, 5000 tons, for London owners; Margot, cargo, 4542 tons, for the Kaye Steamship Company, Ltd., London; Vizagapatam, hopper dredger, 2272 tons, for the Government of India; and a motor launch of 4 tons for British owners. New contracts announced during October include the following:—Three turbine steamers for the Irish Channel service of the London, Midland and Scottish Railway Company, to be built by Messrs. Denny, Dumbarton; one oil tanker, for British Tankers, Ltd.; three cargo steamers, for the Scindia Steam Navigation Company, of Bombay, by Lithgows, Ltd., Port-Glasgow; and a large cargo steamer for the Moss Line, Liverpool, by Harland and Wolff, Ltd., Greenock.

Steel and Iron.

The steel and iron trades remain in a state of stagnation. The number of works in operation is very limited, and at them production is in the main only possible by the utilisation of foreign materials. The works at present closed will not re-open until fuel can be obtained at a reasonable figure, and supplies of raw materials are ample. Steel makers have advanced the minimum prices of certain classes of materials by 5s. per ton and the new quotation for ship plates is £8 2s. 6d., and for sections and joists £7 12s. 6d. per ton for delivery in the Clyde area. Steel sheet makers are very busy, and in some cases are fully booked for months ahead in black and galvanised descriptions. Prices are firmer, owing to dearer costs of materials and to the offering of premiums by buyers. Bar iron makers are chiefly engaged in the production of steel bars from foreign billets. In pig iron, foundry qualities are very scarce, and very high prices are quoted for any small lots available. Fair quantities of hematite are being sent to English foundries for mixing purposes.

Coal.

The demand for coal continues to exceed supplies, and merchants have been endeavouring to secure deliveries from the English Midlands. A fair business has also been done in German briquettes. Outputs of Scottish coal expand steadily, but slowly, and are not yet sufficient to make good the drop in supplies from other sources. Nominal prices are as follows:—Silesian screened coal, 85s. to 87s. 6d.; unscreened, 80s.; Westphalian screened and unscreened, 80s.—all per ton f.o.t. Glasgow, Grangemouth, Bo'ness or Leith. American unscreened, 80s. per ton f.o.t. Glasgow. Westphalian foundry coke, 60s. per ton f.o.t. Grangemouth or Bo'ness. German brown coal briquettes, 58s. 6d. to 60s. per ton f.o.t. Grangemouth, Bo'ness or Leith. Scottish patent fuel, 70s. per ton f.o.b. Glasgow, Grangemouth or Bo'ness, and 1s. per ton more at Leith. Scottish screened coal, 85s.; triping, 70s. to 75s.; and dross, 52s. 6d.—all per ton in truck at pit. English screened coal, 85s.; unscreened, 65s. to 70s.—all per ton delivered in the Glasgow district.

Scottish Miners' Wages.

At a meeting of the Executive Committees of the four Scottish Coalowners' Associations it was agreed to continue the present rate of wages during the month of November. The rates in operation are the same as in April, with an eight hours instead of a seven hours' working day.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

The Coal Outlook.

There are now close on 20,000 men at work in the South Wales coalfield, which is less than one-tenth of the number employed before the stoppage. The increase as compared with a week ago is about 1000. At this rate it will, of course, be a long time before the conditions become anything like normal, but the feeling prevails that this week and next will see a greater return to work on the part of the miners, even if their leaders make no headway towards a settlement. It is, of course, dangerous to say what is likely to happen, except that, assuming that the stoppage comes to an end by the middle of this month, it is pretty generally recognised that there can be extremely little export business this year. It will be a week or two before the bulk of the collieries are in working order and coals on any scale are produced, and in view of the control which will be exercised by the authorities over the coals available, in order to make sure that home requirements are met first, it is impossible to say what coals will be obtainable for export purposes, which makes it very difficult for business men to enter into sales ahead without incurring very grave risks. In the first place most of the colliery salesmen are still declining to make any firm offers for supplies of coal when work is resumed, and in the second place, exporters are faced with a very deep problem as to what rates of freight are likely to be. It is estimated that the coal carrying trade from America has attracted about 600 ships in the course of the last few months. An unprecedented quantity of tonnage is committed to carry American coals right up to the middle of January next. It is consequently very difficult to say what amount of tonnage may be available to lift coals from this district when work begins again in South Wales. The fact that bunker coals have advanced to about three or four times the price prevailing before the stoppage and are likely to remain high, comparatively speaking, for some months, will mean that rates of freight will be on a corresponding level. That being the case most firms are waiting until the conditions become settled before they show any disposition to quote for business on a c.i.f. basis.

Coal Imports.

The average quantity of foreign coals coming into South Wales ports has been about 60,000 tons weekly, but last week the quantity was far exceeded, inasmuch as the amount was well over 100,000 tons, and at the beginning of this week there were over thirty steamers discharging at the various local ports. Between 60 and 70 per cent. of the coals were from America. It is almost impossible to obtain prompt supplies of continental coals, particularly Westphalian qualities, owing to the fact that restrictions are being placed on the export of continental coal. All countries are now feeling the shortage of fuel supplies, and prices have now reached such an abnormally high level that many industries on this side cannot continue operating. Silesian large coals are quoted at round about 80s. c.i.f., while German brown-coal briquettes are 67s. 6d. to 70s. c.i.f., and American run of the mine coals command 75s. to 80s. c.i.f. A circular issued by a German firm points out that supplies of coal have now become so scarce that the Syndicate is not making any fresh offers for coals for early shipment, and the only way left open for further business will be on the basis of closing contracts over several months, such as for coals and patent fuel from January to June, as earlier is impossible; for foundry coke from November to April, whilst brown-coal briquettes are still available for prompt loading. It is evident from this that the Germans are out for capturing all the business they can, inasmuch as the circular in question significantly states in conclusion that for such contracts there is every hope of successfully making business at "comparatively low prices."

New Regulations.

So far as Welsh coals are concerned the price of large for household purposes delivered at Cardiff remains at 53s., and through coals are 50s., but for other purposes prices range up to 60s. for large. For the future, however, no releases will be granted to industrial works except in very special circumstances. The secretary to the Emergency Committee for this district—Mr. Finlay Gibson—has issued a circular recently stating that permits will be issued for the release of coals for the priority services as follows:—Large coal (destinations in Monmouthshire and South Wales only), household purposes, gasworks; through coal (destinations in Monmouthshire and South Wales and South-Western counties), gasworks, household purposes, electrical works, hospitals, workhouses and similar institutions, flour milling, yeast-making, bakeries, cold stores, and ice factories, milk factories and depôts; small coal (destinations in Monmouthshire and South Wales only), patent fuel works, essential services and industrial works. These arrangements are to apply until such time as applications and permits can be dispensed with.

Patent Fuel Manufacture.

The production of patent fuel in South Wales, which in normal times is on a very substantial scale, is now very restricted for the reason that the supplies of small coals are so difficult to get. Furthermore, the price of pitch is a very serious factor in the position. This commodity, of which 10 per cent. to the ton must be calculated in the manufacture of fuel, has advanced to the extremely high figure of approximately £10 per ton, which is the highest price touched since 1923. The shortage of pitch has principally been brought about by the coal stoppage, which has resulted in by-product manufacture at nearly all colliery plants being suspended, whilst the large quantity of tar used in road making is responsible to a material extent for the present position.

Offer Rejected.

The terms offered by the proprietors of the Empire Colliery, Glynneath, to their workmen for an immediate resumption of work, having been rejected, the owners have now withdrawn their offer and have given notice to all the officials at the collieries as from Monday next. The offer was based on a 7½-hour day.

Tin-plate Trade.

The difficulty of securing adequate supplies of coal and steel is handicapping the production of tin-plates, and prices show a hardening tendency. Up to 26s. basis I.C. f.o.b. works port has been paid for prompt supplies, and prices run from 24s. to 24s. 6d. for deliveries during the first three months of next year. The question of the 7½ per cent. *ex gratia* bonus to workmen, which employers had given notice to discontinue on the 6th inst., came up for discussion on Tuesday at a meeting of the Joint Standing Committee of the Industrial Council. No decision, however, was reached, and the matter was adjourned to a further meeting to be held next month.

Steel Smelters' Wages.

The secretary of the Iron and Steel Trades' Confederation announces that under the latest ascertainment of selling prices of steel, the smelters' sliding scale as from Sunday next will be advanced 5 per cent.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

Richard Garrett and Sons, Ltd., of Leiston, ask us to announce that negotiations, which have been in progress for some time, have now been completed, and that by them they have acquired the whole of the interests of the Caledon Motor Company, Ltd., of Glasgow. In future all types of the Caledon lorry will be manufactured at their works at Leiston.

In connection with the liquidation of Fuller's United Electric Works, Ltd., which was announced some time ago, we are asked to state:—(*a*) That the Accumulator Works Department of the company has been acquired by Mr. E. W. Sudlow, late secretary of the company, Mr. A. P. Welch, late chief technical engineer, and Mr. H. F. Wynn, late general sales manager; and that a company is shortly being registered under the name of "Fuller Accumulator Company (1926), Ltd.," to carry on the manufacture of the accumulator; (*b*) that the wire and cable department of the company has been sold, and will in future be run on a larger scale than in the past; and (*c*) that Sir John Mann will continue to act for the present as receiver and manager in connection with the ebonite and carbon black departments of the late company.

CONTRACTS.

Loudon Brothers, Ltd., of Johnstone, have received an order for four large planing machines for the New Zealand Railway workshops. This order is in addition to those which the firm has already in hand for these workshops, embracing wheel, axle and engine lathes.

Foamite Firefoam, Ltd., 24–26, Maddox-street, Regent-street, London, W. 1, has just received orders to supply complete Foamite installations for the five Southern Railway vessels—ss. Dinard, St. Briac, Maid of Kent, Isle of Thanet, and Biarritz.

Standard Telephones and Cables, Ltd., of Bush House, Aldwych, London, W.C. 2, has been commissioned by the Irish Post Office to supply a broadcasting station for Cork. The station will be of a similar type to that now in operation at Birmingham, but of an approximate 3 kilowatt Geneva rating.

Faraday House Old Students' Dinner.—The annual dinner of the Faraday House Old Students' Association was held at the Hotel Cecil on October 29th, Mr. L. J. Kettle, M.I.E.E., electrical engineer to the Dublin Corporation, being in the chair. The toast of "Faraday House" was proposed by Professor W. H. Eccles, F.R.S., the President of the Institution of Electrical Engineers. He pointed out that this country had considerable leeway to make up before its electrical development equalled that of its rivals. The new Government schemes should open the way to a much greater use of applied electricity, and progress in that direction could only be made if a large supply of able and competent junior engineers, such as those turned out by Faraday House, was always available. In reply, the Principal, Dr. Alexander Russell, F.R.S., mentioned that the number of students at Faraday House was now 280, and that the College had a record entry this term. Mr. Gilbert Scott Ram proposed the toast of "The Guests," and to it Sir Philip Dawson and Mr. R. A. Chattock responded. Mr. Kettle, acknowledging the reception of his toast, proposed by Mr. W. Hewat, of the Irish Free State, said that in his opinion the prospects of electricity supply in Ireland were very bright and that English manufacturers could reap a rich harvest there provided that their prices were no higher than those of their foreign competitors. An excellent musical programme concluded an enjoyable evening. Over 200 members and guests were present.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. Coast—	
Native	18/6 to 21/-
(1) Spanish	18/6 to 21/-
(1) N. African	18/6 to 21/-
N.E. Coast—	
Native	—
Foreign (c.i.f.)	21/6

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) Scotland—		
Hematite	—	—
No. 1 Foundry	‡4 15 0 to 5 0 0	—
No. 3 Foundry	‡4 10 0	—
‡ *For delivery after resumption of work at furnaces.*		
N.E. Coast—		
Hematite Mixed Nos.	4 8 6	4 8 6
No. 1	4 9 0	4 9 0
Cleveland—		
No. 1	6 5 0	6 5 6
Silicious Iron	6 5 0	6 5 6
No. 3 G.M.B.	6 0 0	6 0 6
No. 4 Foundry	5 19 0	5 19 6
No. 4 Forge	5 18 6	5 19 0
Mottled	5 17 6	5 18 0
White	5 17 6	5 18 0
Midlands—		
(3) Staffs.—		
All-mine (Cold Blast)	10 10 0	—
North Staffs. Forge	3 17 6	—
„ „ Foundry	4 7 6	—
(3) Northampton—	(*None offered.*)	
Foundry No. 3	3 5 0 to 3 10 0	
„ Forge	2 16 0 to 2 17 0	
(3) Derbyshire—	(*None offered.*)	
No. 3 Foundry	3 7 6 to 3 15 0	
Forge	3 2 9 to 3 5 6	
(3) Lincolnshire—	(*None offered.*)	
No. 3 Foundry	3 8 0	—
No. 4 Forge	3 5 6	—
Basic	3 6 0	—
(4) N.W. Coast—		
N. Lancs. and Cum.—		
Hematite Mixed Nos.	4 15 6 (*a*)	—
	4 18 6 (*b*)	—
	5 2 0 (*c*)	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
Scotland—		
Crown Bars	12 0 0	11 0 0
Best	—	—
N.E. Coast—		
Common Bars	11 15 0	—
Lancs.—		
Crown Bars	12 0 0	—
Second Quality Bars	10 15 0	—
Hoops	14 0 0	—
S. Yorks.—		
Crown Bars	12 10 0	—
Best Bars	13 10 0	—
Hoops	14 10 0	—
Midlands—	(*Prices nominal.*)	
Crown Bars	11 5 0 to 11 10 0	
Marked Bars (Staffs.)	14 0 0	—
Nut and Bolt Bars	10 5 0 to 10 10 0	
Gas Tube Strip	12 10 0	—

STEEL.

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) Scotland—		
Boiler Plates	11 0 0	—
Ship Plates, ½in. and up	8 2 6	7 0 0
Sections	7 12 6	6 5 0
Steel Sheets, under $^{3}/_{16}$in. to ¼in.	12 0 0 to 12 10 0	
Sheets (Gal. Cor. 24 B.G.)	—	£17 5 0 to 18 5 0

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
N.E. Coast—		
Ship Plates	8 12 6	—
Angles	8 12 6	—
Boiler Plates	12 0 0	—
Joists	8 0 0	—
Heavy Rails	8 10 0	—
Fish-plates	12 0 0	—
Channels	10 5 0	£9 to £9 5
Hard Billets	8 2 6	—
Soft Billets	7 5 0	—
N.W. Coast—		
Barrow—		
Heavy Rails	8 0 0†	—
Light Rails	8 5 0 to 8 10 0	
Billets	8 0 0 to 11 10 0†	
Manchester—		
Bars (Round)	9 10 0	—
„ (Small Round)	10 0 0	—
Hoops (Baling)	11 0 0	11 0 0
„ (Soft Steel)	10 15 0	10 15 0
Plates	8 5 0 to 8 12 6	
„ (Lancs. Boiler)	11 10 0 to 12 0 0	
Sheffield—		
Siemens Acid Billets	10 0 0	—
Bessemer Billets	11 0 0	—
Hard Basic	8 12 6	—
Intermediate Basic	8 2 6	—
Soft Basic	7 5 0	—
Hoops	12 0 0	—
Soft Wire Rods	9 10 0	—
Midlands—		
Small Rolled Bars	8 15 0	—
Billets and Sheet Bars	—	
Sheets (20 W.G.)	11 10 0 to 12 0 0	
Galv. Sheets, f.o.b. L'pool	17 5 0 to 17 10 0	
Angles	8 12 6 to 8 17 6	
Joists	8 12 6 to 8 17 6	
Tees	9 12 6 to 10 17 6	
Bridge and Tank Plates	—	
Boiler Plates	—	

NON-FERROUS METALS.

Swansea—	
Tin-plates, I.C., 20 by 14	21/6 to 25/6
Block Tin (cash)	207 5 0
„ (three months)	203 15 0
Copper (cash)	57 15 0
„ (three months)	58 12 6
Spanish Lead (cash)	29 12 6
„ (three months)	29 11 3
Spelter (cash)	33 8 9
„ (three months)	33 7 6
Manchester—	
Copper, Best Selected Ingots	65 17 6
„ Electrolytic	67 0 0
„ Strong Sheets	92 0 0
„ Tubes (Basis Price)	0 1 1
Brass Tubes (Basis Price)	0 1 0
„ Condenser	0 1 2½
Lead, English	31 5 0
„ Foreign	30 2 6
Spelter	33 15 0

FERRO ALLOYS.

(*All prices now nominal.*)

	Per Ton.	Per Unit.
Tungsten Metal Powder	1/9 to 1/10 per lb.	
Ferro Tungsten	1/5 per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£23 0 0	7/6
„ „ 6 p.c. to 8 p.c. „	£22 0 0	7/3
„ „ 8 p.c. to 10 p.c. „	£20 15 0	6/6
„ „ Specially Refined		
„ „ Max. 2 p.c. carbon	£37 0 0	12/6
„ „ „ 1 p.c. „	£43 5 0	15/-
„ „ „ 0·70 p.c. carbon	£54 0 0	17/6
„ „ „ carbon free	1/5d. per lb.	
Metallic Chromium	3/- per lb.	
Ferro Manganese (per ton)	£15 for home, £15 for export	
„ Silicon, 45 p.c. to 50 p.c.	£10 10 0 scale 5/- per unit	
„ „ 75 p.c.	£15 17 6 scale 6/- per unit	
„ Vanadium	14/9 per lb.	
„ Molybdenum	5/3 per lb.	
„ Titanium (carbon free)	0/11½ per lb.	
Nickel (per ton)	£170	
Cobalt	10/- per lb.	
Aluminium (per ton)	£112	

FUELS.

SCOTLAND.

	(*Prices nominal.*)	Export.
Lanarkshire—		
(f.o.b. Glasgow)—	Steam	15/9
„ „	Ell	16/6
„ „	Splint	16/6 to 17/-
„ „	Trebles	15/9
„ „	Doubles	14/- to 14/6
„ „	Singles	13/9
Ayrshire—		
(f.o.b. Ports)—	Steam	16/9
„ „	Jewel	17/- to 17/6
„ „	Trebles	17/-
Fifeshire—		
(f.o.b. Methil or Burntisland)—	Steam	12/6 to 14/9
Screened Navigation		21/-
Trebles		14/- to 15/-
Doubles		14/-
Singles		13/- to 13/6
Lothians—		
(f.o.b. Leith)—	Best Steam	14/- to 14/3
Secondary Steam		13/6
Trebles		14/6 to 14/9
Doubles		13/6
Singles		13/6

ENGLAND.

	Inland. (*Nominal, none on offer.*)
(8) N.W. Coast—	
Steams	*No quotation.*
Household	„ „
Coke	„ „
Northumberland—	
Best Steams	16/-
Second Steams	14/6 to 15/-
Steam Smalls	8/- to 8/6
Unscreened	13/- to 13/6
Household	20/- to 22/-
Durham—	
Best Gas	18/6 to 19/-
Second	15/- to 15/6
Household	20/- to 22/-
Foundry Coke	18/- to 20/-
Sheffield—	
Best Hand-picked Branch	31/- to 34/- —
Barnsley Best Silkstone	28/- to 30/- —
Derbyshire Best Brights	26/- to 28/- —
„ „ House	24/- to 25/- —
„ „ Large Nuts	17/- to 20/- —
„ „ Small	12/6 to 14/- —
Yorkshire Hards	17/- to 19/6 —
Derbyshire Hards	16/- to 19/- —
Rough Slacks	10/- to 12/6 —
Nutty Slacks	7/6 to 9/- —
Smalls	3/6 to 6/- —
Blast-furnace Coke (Inland)*	— —
„ „ (Export)	f.o.b. 16/- to 17/-

(9) SOUTH WALES.

	(*All prices nominal.*)
Cardiff—	
Steam Coals :	
Best Smokeless Large	26/- to 27/-
Second „ „	24/6 to 25/6
Best Dry Large	24/- to 25/-
Ordinary Dry Large	21/- to 22/-
Best Black Vein Large	25/6 to 26/-
Western Valley Large	24/6 to 25/-
Best Eastern Valley Large	24/- to 25/-
Ordinary „ „	23/6 to 24/-
Best Steam Smalls	17/- to 18/-
Ordinary „	16/- to 17/-
Washed Nuts	19/- to 20/-
No. 3 Rhondda Large	26/6 to 27/-
„ „ Smalls	18/- to 18/6
No. 2 „ Large	24/- to 25/-
„ „ Through	20/- to 21/-
„ „ Smalls	15/- to 16/-
Foundry Coke (export)	40/- to 50/-
Furnace Coke (export)	25/- to 30/-
Patent Fuel	42/6 to 45/-
Pitwood (ex ship)	32/6 to 35/-
Swansea—	
Anthracite Coals :	
Best Big Vein Large	39/- to 40/-
Seconds	32/6 to 35/-
Red Vein	27/- to 29/-
Machine-made Cobbles	47/6 to 50/-
Nuts	47/6 to 50/-
Beans	42/6 to 44/-
Peas	23/- to 25/-
Breaker Duff	7/6 to 8/-
Rubbly Culm	12/6 to 13/6
Steam Coals :	
Large	22/6 to 24/6
Seconds	20/- to 22/-
Smalls	11/- to 15/-
Cargo Through	16/6 to 17/6

(1) Delivered. (2) Net Makers' works. (3) f.o.t. Makers' works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire and Ayrshire.

(6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/- extra delivered England. (7) Export Prices—*f.o.b.* Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. * For blast-furnaces only, 17/-, with fluctuations according to analysis; open market 17/6 to 19/- at ovens. † Latest quotations available. (*a*) Delivered Glasgow. (*b*) Delivered Sheffield. (*c*) Delivered Birmingham.

French Engineering Notes.

(From our Correspondent in Paris.)

The Steel Industry.

THE extent to which the British miners' strike is affecting favourably the situation of continental steel producers is seen in the decision of the new Steel Cartel to raise the maximum production for the ensuing three months to 8,000,000 tons, as it was feared that a continuance of the demand for iron and steel from Britain would diminish the supplies available on the Continent. Prices are hardening, without undergoing an official advance, and, as a matter of fact, it is very difficult to fix prices at a time when the franc is passing through what is believed to be a period of stabilisation. The steady improvement in currency values has raised general hopes of a complete recovery, but it is so far impossible to foresee the conditions under which the recovery will take place, that everyone preserves an attitude of expectancy. The danger at the moment is a too sudden appreciation of the franc, which would cause temporary disaster all round. The general optimism does not take into account the possibility of a setback. Regarded as a whole, the situation is by no means safe, as the future may very well reserve surprises, and in view of the problematic outlook consumers will not do more than cover urgent requirements. So far there has been a good export trade in iron and steel, but it is being checked by the appreciation of the franc as well as by the hardening values, and if it were not for the restricted production in Great Britain, the situation would not be so good as it is. In the engineering branches business is very scarce, and many firms experience great difficulty in finding employment for their hands. The only thing that prevents a feeling of despondency is the belief that the attempts to organise the industrial situation in Europe, and to improve the financial position at home, will produce good results in the early future.

The Steel Union.

The steel producers in Central Europe have not yet succeeded in arranging amongst themselves the conditions under which they can adhere to the Steel Cartel. So many firms are claiming a larger quota than can be allotted to them, that the situation appears hopeless unless they can be induced to see that their interests lie in a combined effort to organise a more stable basis for trade. In Czecho-Slovakia the firm of Albert Hahn, of Oderberg, is standing in the way of a settlement, and in Hungary producers are not satisfied with the participation offered them, while in Poland the steel producers of Upper Silesia, who have been doing very well, are asking for more than can be allotted to them. In cases in which the production will have to be largely reduced, it is obvious that great difficulties will be experienced in coming to a satisfactory decision. It is nevertheless hoped that the Central European producers will finally agree to an arrangement which will enable them to join the Cartel, and a meeting will be held shortly in Vienna with a view of seeing if it is possible to arrive at a definite agreement.

Concrete Suspension Bridge.

Reinforced concrete is extending its applications in a way that is narrowing down the unavoidable use of steel for structural purposes, and in the building of a suspension bridge it has encroached even upon a domain in which steel seemed likely to enjoy a complete monopoly. At Laon, which had to be largely reconstructed after the war, it was necessary to build a viaduct as an approach to the railway station and to continue it with a suspension bridge over the railway. The viaduct itself has a width of 12 m., and is supported by piers with spherical expansion articulations. In many ways concrete bridges are following more closely the principles of steel construction. Extending from the viaduct is the suspension bridge 75 m. long, with the central piers of large section carrying, in place of the usual steel cables, iron rods embedded in concrete. The vertical iron roads carrying the platform are also, of course, attached directly to the suspension rods and are similarly encased in concrete. It is, therefore, in reality a metal suspension with concrete to insure its preservation and, at the same time, to give a sense of harmony to the construction. Its appearance is novel, and the concealment of the metal suspension rods leaves, perhaps, a sense of insecurity.

Railway Accidents.

Of the railway accidents taking place in this country a fair proportion are certainly due to the derailing of trucks and coaches and to the breaking of couplings, and that condition of things must be attributed to the necessity of the railway companies to keep down their expenditure in order to avoid deficits which can no longer be made good by the State. A fair amount of rolling stock has been obtained from Germany recently on account of reparations, but the Government has been obliged, because of the opposition of rolling stock builders at home, to limit the German supplies to what is strictly necessary, and the policy of national economy now being carried out does not permit of orders for rolling stock being distributed. The wagon-building shops have been destitute of work for a long while past. Consequently, much of the rolling stock is defective, and ordinary passenger trains on the State and some other lines are still made up of heavy and light coaches. The accident to the express from Calais to Paris just outside Liancourt was due to the derailing of a truck inside the station, which necessitated the train from Paris to Lille being switched on to the up line while traversing the station. There is no explanation as to how the accident happened, for the driver of the Calais–Paris train declares that the signal was not against him. The down train was masked by the bridge, and although the Calais–Paris train was approaching the station at less than 20 miles an hour, the driver states that the brakes failed to act sufficiently to enable him to stop when he saw the down train crossing over from the up line. The locomotive cut the Lille train in half, and demolished a dining car, killing two passengers and injuring eighteen others.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

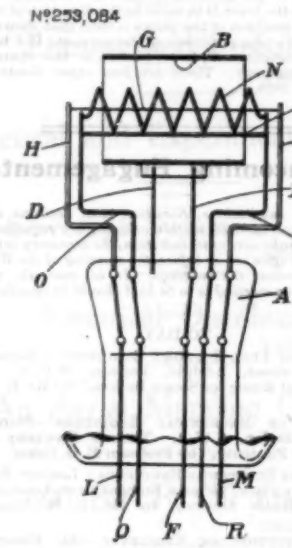
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C. at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

TELEGRAPHS AND TELEPHONES.

253,084. April 27th, 1926.—IMPROVEMENTS IN OR RELATING TO ELECTRODES FOR ELECTRON DISCHARGE TUBES OR THERMIONIC VALVES, N. V. Philips' Gloeilampenfabrieken, of Emmasingel 6, Eindhoven, Holland.

This invention relates to thermionic valves and in particular to electrodes for such valves, consisting of a continuous conductor bent either helically or in the form of a zigzag. Electrodes of this class present several difficulties during the process of exhaustion of the valve. In order to remove all the occluded gases from them it is necessary to heat them, and it has been proposed to do this by passing an electric current through the electrodes by means of leading-in wires during the process of exhaustion. However, on account of the high temperature which must be obtained, if all the occluded gases are to be removed, there is considerable risk of the electrode sagging, and so lessening the accuracy of the construction of the valve. According to this invention, an electrode, consisting of a wire bent helically or in a zigzag, is attached to a supporting rod or backbone constructed of a material having considerably higher specific resistance than the electrode itself. By this means a current may be led to the ends of the electrode during the process of exhaustion of the valve, and the greater part of this current will pass through the electrode wire, a relatively small part passing through the

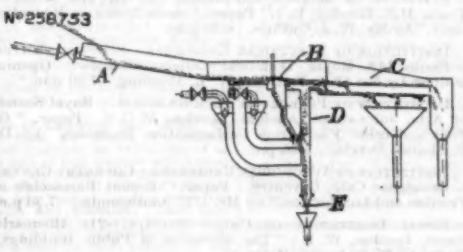


backbone, since the latter has a much higher resistance than the electrode. The effect of this current, however, is to heat both the electrode and its backbone almost equally, so that the occluded gases are removed equally from both. The drawing illustrates a three-electrode thermionic valve, of which the envelope is nearly entirely broken away. The pinch or re-entrant portion A has sealed into it in the usual manner the various supports and leading-in wires. The cylindrical anode B is carried by supports D E, the latter being connected to the leading-in wire F. The cathode G, in the form of a straight wire arranged to lie on the axis of the anode B, is carried by supports H and K connected respectively to leading-in wires L and M. Surrounding the cathode is a grid N constructed of a nickel wire wound in a helix, and supported at its end by supports O and P connected respectively to leading-in wires Q and R. These supports also carry a small rod S of constantan. Each of the turns of the grid N is attached to the supporting rod S, preferably by spot welding. Since the supporting rod S is of considerably greater resistance than the grid N, it will be appreciated that when a potential difference is applied to the leading-in wires Q and R currents will flow in parallel through the grid and its supporting rod, but the current through the grid N will be larger than that through the supporting rod S.—*September 30th*, 1926.

MINING MACHINERY.

258,753. November 28th, 1925.—WASHING COAL AND ORES L. Hoyois, 92, Chausse de Ransart, Gilly, Belgium.

In this coal washer there are two distinct sections. The coal and water are fed down a trough A and encounter an adjustable weir B in the top of which there is a transverse opening. Heavy particles, such as shale, fall through this opening, while the

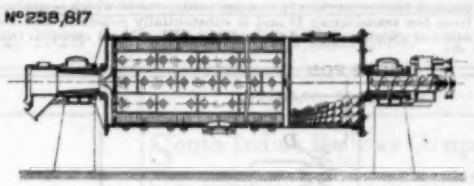


lighter coal is carried forward to the classifying trough C. The shale may carry with it some coal, so it is subjected to a rising current of water in the column D. In this way the coal is separated and carried on to the trough C, while the shale is discharged at E. The relative proportions of the several parts are given in the specification.—*September 30th*, 1926.

CRUSHING AND GRINDING.

258,817. May 18th, 1926.—BALL MILLS, R. Wilson, 141, Summergangs-road, Kingston-upon-Hull.

This specification is, to our mind, noteworthy on account of the fact that the illustrations are not accompanied by any reference letters, which in many others are wholly unnecessary. The essence of the idea is to line a ball mill with plates grooved

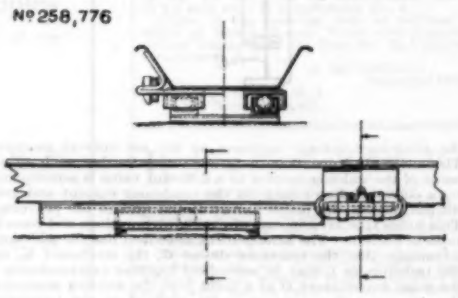


circumferentially with grooves of the same radius of the balls, in order to increase the contact area between the two. The illustration shows a mill having a preparatory compartment of normal design and a final reducing section lined with the proposed form of plates.—*September 30th*, 1926.

CRANES AND CONVEYORS.

258,776. February 6th, 1926.—JIGGER CONVEYORS, J. McWhinnie, 56, Gibson-street, Willington-square, Willington-on-Tyne.

The inventor proposes to minimise the power required for working a jigging conveyor by mounting it on ball bearings.

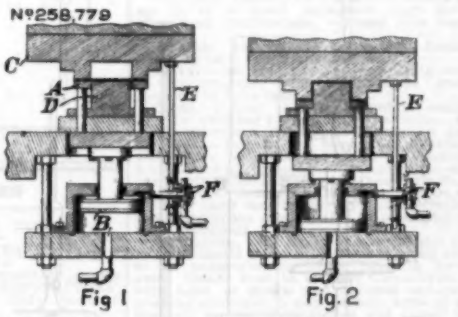


These bearings take the form of two longitudinal troughs, one inverted above the other, as shown in the drawing, with balls interposed between them. It is suggested that the parts should be so arranged as to prevent dust acumulating between the two troughs.—*September 30th*, 1926.

MACHINE TOOLS AND SHOP APPLIANCES.

258,779. February 9th, 1926.—PRESSES FOR DRAWING SHEET METAL, *H. D. Fitzpatrick*, 94, *Hope-street, Glasgow*.

This invention is concerned with presses equipped with a draw ring, for holding the blank while it is being operated upon. This ring is shown at A, and is supported by the hydraulic ram B. The female die C is carried by the press ram and the male die D by the bolster. In Fig. 1 the blank has just been inserted



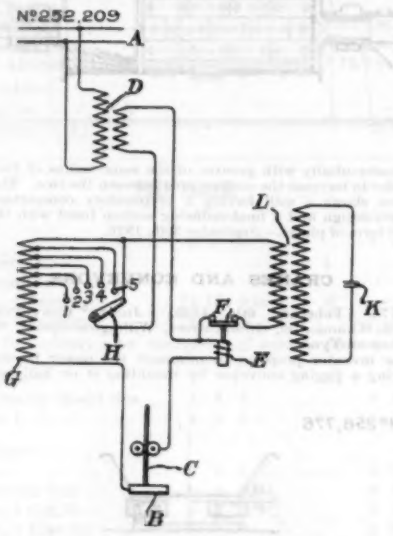
and is held by the draw ring being pressed upward by the ram B. The press ram then descends, forming the blank, and pushing in front of it the draw ring—against the hydraulic pressure. At the end of the stroke the tappet rod E reverses the valve F—as shown in Fig. 2—thus admitting pressure water above the ram B. As, however, the effective area there is less than below, there is an upward thrust, and the finished article is ejected as the press ram rises.—*September 30th*, 1926.

WELDING.

252,209. May 18th, 1926.—SYSTEM FOR THE IMPROVEMENT OF THE POWER FACTOR OF ELECTRIC WELDING AND OTHER REACTANCE CONTROLLED CIRCUITS, *The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C.* 2.

In the operation of an arc welding system, it is desirable that means be provided for stabilising the arc and for adjusting the current to different values. This is ordinarily accomplished by an adjustable inductance. The use of inductance in series with the arc naturally results in a low power factor load. In accordance with this invention, a circuit containing a condenser is associated with the welding or other load circuit for improving the power factor, and means for controlling the system are arranged to produce simultaneous and corresponding changes in the volt-ampères of the condenser and welding or other load circuits. Means are also provided for interrupting the condenser circuit upon the interruption of the supply of current or when the current decreases below a predetermined value. From the leads A current is supplied to an electric arc between the work B and electrode C, through a circuit comprising the secondary winding of transformer D operating coil E of a contactor F, and an adjustable reactance device G, provided with taps 1, 2, &c., and a contact member H adapted to co-operate with the contacts of these taps. A condenser K is arranged to be connected in shunt to the welding circuit through the contactor F and an adjustable portion of the reactance device G. As shown, a step-up transformer L is provided for raising the voltage applied to the condenser terminals. In the illustrated position of the contact arm H the reactance device G serves merely as a

reactor in series with the arc and only the secondary voltage of the main transformer D is impressed on the primary circuit of the condenser transformer L. Movement of the contact member H into engagement with the contact of tap 5, however, causes the reactance device G also to operate as an auto-transformer as regards voltage relationships by which an additional voltage, increasing as the contact member is moved toward the tap 1, is applied to the circuit comprising the primary winding of transformer L, switch F and the secondary winding of transformer D. The voltage applied to transformer L with this connection thus comprises two components, one of which is applied from the transformer D and is substantially constant, and the other of which is applied through the device G and varies so that

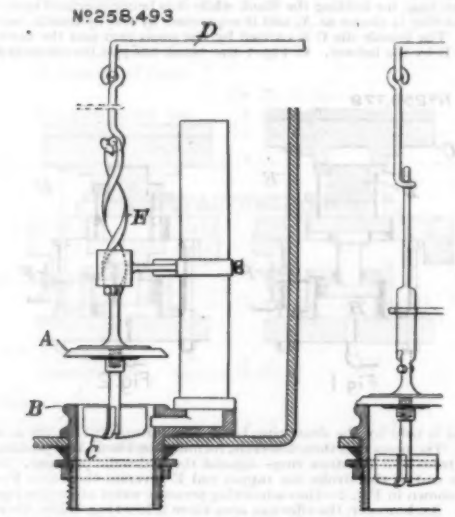


the condenser voltage increases as the arc current increases. This method of operation is of advantage in that each adjustment of the welding current to a different value is accompanied by a corresponding change in the condenser current and great fluctuations in the power factor of the system are prevented. This holds true even in case of entire interruptions and resumptions of current. The arrangement described has the additional advantage that the reactance device G, the condenser K, and the transformer L may be assembled together independently of the main transformer D at a point near the welding apparatus, thus ensuring that current is transmitted to the immediate vicinity of the welding set at a high power factor.—*September 30th*, 1926.

MISCELLANEOUS.

258,493. March 20th, 1926.—Outlet Valves for Flushing Tanks, R. G. Howson, Eastwood Sanitary Works, Hanley, Stoke-on-Trent.

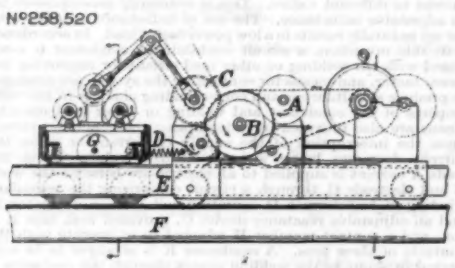
This invention is concerned with the outlet valves of flushing cisterns, and has for its object an arrangement whereby the valve is automatically kept open while water is flowing through the outlet, whereas the valve is free to close when the flow



ceases. For this purpose the valve A, which works in conjunction with the seating B, is provided with a set of curved vanes C. When the valve is opened deliberately by means of the lever D the flow of water past these vanes C tends to turn the valve in a counter-clockwise direction and to keep it open with the assistance of the steep-pitch screw E. When the flow of water ceases the valve closes again under the action of gravity.—*September 23rd*, 1926.

258,520. May 27th, 1926.—Manufacture of Wire Glass, *H. Wade*, 111, *Hatton-garden, London, E.C.* 1.

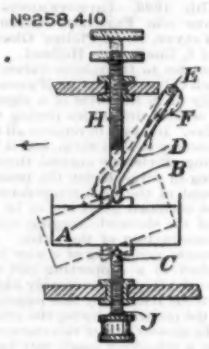
The object of this invention is to produce a corrugated sheet



of glass reinforced with wire mesh. The molten glass is poured between the rolls A and B and the wire mesh is supplied over the roll C, which is provided with projections that press the wire into the interior of the sheet of glass. The sheet is then smoothed out by the roll D and is deposited on the table E as the truck carrying the rolls moves along the track F. The table is corrugated and the glass is laid on it, "while the interior portion of the sheet is sufficiently plastic by heat to permit twists of the mesh to stretch, and while the exterior of the sheet is sufficiently solid by cooling upon bending to retain its form." The glass settles down into the corrugations under the influence of gravity, and is subsequently consolidated by the press G, which is operated step by step.—*September 23rd*, 1926.

258,410. August 25th, 1925.—Improvements in and relating to Variable Electric Condensers and the like, Frederick George Warbrook, of Hall Ing, Honley, Huddersfield.

Each end-plate is provided with a conical depression A for supports B or C. The former is carried by a lever D, pivoted at E and acted upon by a spring F tending to swing the lever in the direction of the arrow. The upper screw H permits the



pivotal position of the lever to be varied. Withdrawal of the screw H permits the lever D to move in the direction of the arrow and the relative position of the plates is then that shown dotted. If the relative starting positions of the supports H J be varied, consequent variations will be apparent in the characteristic curve of the condenser. There are four other illustrations.—*September 23rd*, 1926.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

Institution of Fuel Economy Engineers.—Royal Society of Arts, John-street, Adelphi, London, W.C. 2. Lecture, "Pulverised Fuel Firing for Steam Boilers," by Mr. R. Jackson. 6 p.m.

Institution of Mechanical Engineers.—Storey's-gate, Westminster, London, S.W. 1. Thomas Hawksley Lecture, "Elasticity and Plasticity," by Professor E. G. Coker. 6 p.m.

Institution of Electrical Engineers: London Students' Section.—Savoy-place, Victoria Embankment, London, W.C. 2. "The Rugby Radio Station," by Mr. E. H. Shaughnessy. 6.15 p.m.

Junior Institution of Engineers.—39, Victoria-street, London, S.W. 1. Lecturette, "Steel Castings and their Relation to Mechanical Engineering," by Mr. R. Lowe. 7.30 p.m.

North of England Institute of Mining and Mechanical Engineers: Associates' and Students' Section.—Electrical Engineering Lecture Theatre, Armstrong College, Newcastle-on-Tyne. "Some Recent Methods of Measurement," by Mr. B. A. Robinson. 7.15 p.m.

SATURDAY, NOVEMBER 6TH.

Institute of British Foundrymen: Birmingham, Coventry and West Midlands Branch.—The Engineers' Club, 13, Waterloo-street, Birmingham. "Labour Conditions in American Foundries," by Mr. J. T. Kay. 6.30 p.m.

Institute of British Foundrymen: Lancashire Branch.—College of Technology, Manchester. Paper, "The Manufacture and Properties of Blackheart Malleable Castings," by Mr. A. E. Peace. 4 p.m.

MONDAY, NOVEMBER 8TH.

Institute of Metals: Scottish Local Section.—Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow. Discussion on "Die Casting." 7.30 p.m.

Institution of Automobile Engineers.—The College, Loughborough. Loughborough Graduates' meeting. Address by the chairman, Mr. S. J. Young. 7.30 p.m.

Institution of Automobile Engineers: Birmingham Centre.—Chamber of Commerce, New-street, Birmingham. Paper, "Recent Researches on Friction and Lubrication," by Mr. J. E. Southcombe. 7 p.m.

Surveyors' Institution.—12, Great George-street, Westminster, London, S.W. 1. Opening address by the President, Mr. D. Watney. 8 p.m.

TUESDAY, NOVEMBER 9TH.

Institute of Marine Engineers.—85–88, The Minories, Tower Hill, London, E. 1. Paper, "Some Notes on Reduction Gear," by Mr. W. J. Guthrie. 6.30 p.m.

Institution of Electrical Engineers: Scottish Centre.—Room 149, Royal Technical College, Glasgow. Opening address by the Chairman, Mr. W. L. Winning. 7.30 p.m.

Institution of Petroleum Technologists.—Royal Society of Arts, John-street, Adelphi, London, W.C. 2. Paper, "Oil Fuel and other Fuels from Carbonisation Processes," by Dr. F. Mollwo Perkin. 5.30 p.m.

Institution of Automobile Engineers: Coventry Centre.—Broadgate Café, Coventry. Paper, "Recent Researches on Friction and Lubrication," by Mr. J. E. Southcombe. 7.30 p.m.

Royal Institution of Great Britain.—21, Albemarle-street, London, W. 1. "The Acoustics of Public Buildings," by Dr. G. W. C. Kaye. 5.15 p.m.

WEDNESDAY, NOVEMBER 10TH.

Chemical Engineering Group.—Chemical Society's Rooms, Burlington House, Piccadilly, London, W. 1. Paper, "Moulding and Vulcanisation of Rubber Articles," by Mr. H. Willshaw. 8 p.m.

Institution of Civil Engineers.—Great George-street, London, S.W. 1. Informal meeting. Discussion on "Coast Erosion and Sea Defences," introduced by Mr. A. W. Lewis. 6 p.m.

Institution of Electrical Engineers: South Midland Centre.—The University, Edmund-street, Birmingham. Paper, "The Design of City Distribution Systems and the Problem of Standardisation," by Messrs. J. R. Beard and T. G. N. Haldane. 7 p.m.

Institution of Mechanical Engineers: Yorkshire Branch.—Mappin Hall, St. George's-square, Sheffield. Thomas Hawksley Lecture, "Elasticity and Plasticity," by Professor E. G. Coker. 7.30 p.m.

Junior Institution of Engineers.—Visit to the tin-plate printing and box-making works of Barclay and Fry, Ltd. 2.15 p.m.

Royal Society of Arts.—John-street, Adelphi, London, W.C. 2. Inaugural meeting. "International Interests in Raw Materials," by Sir Thomas H. Holland, chairman of the Council. 8 p.m.

THURSDAY, NOVEMBER 11TH.

Institution of Mechanical Engineers: Yorkshire Branch.—Hotel Metropole, Leeds. Thomas Hawksley Lecture, "Elasticity and Plasticity," by Professor E. G. Coker. 7.30 p.m.

Institution of Automobile Engineers.—Cavendish Café, Cornmarket, Derby. Derby Graduates' meeting. Paper, "Engine Lubrication," by Mr. W. Evans. 7.30 p.m.

FRIDAY, NOVEMBER 12TH.

Institute of Metals: Sheffield Local Section.—Applied Science Department of the University, St. George's-square, Sheffield. "Ingots and Ingot Making," by Mr. H. Brearley. 7.30 p.m.

Institute of Metals: Swansea Local Section.—Metallurgical Department, University College, Singleton Park, Swansea. "Zinc Smelting and Recovery of its By-products," by Mr. J. H. Wells. 7.15 p.m.

Institution of Engineering Inspection.—Royal Society of Arts, John-street, Adelphi, London, W.C. 2. Paper, "Further Notes on Ciment Fondu," by Mr. H. J. Davey. 7.30 p.m.

Institution of Mechanical Engineers.—Storey's-gate, Westminster, London, S.W. 1. Informal discussion, "Estimating," introduced by Mr. L. J. T. Wheatley. 7 p.m.

Institution of Municipal and County Engineers.—Visit of the West Midland District to the Enderby and Stoney Stanton Granite Company's quarries at Enderby, Leicester. 2 p.m.

Junior Institution of Engineers.—39, Victoria-street, London, S.W. 1. Annual general meeting. 7.30 p.m.

Manchester Association of Engineers.—The Engineers' Club, Manchester. Paper, "Steel Works Machinery," by Mr. James Smith. 7.15 p.m.

North-East Coast Institution of Engineers and Shipbuilders.—Literary and Philosophical Society's Rooms, Newcastle-upon-Tyne. Resumed discussion on "How Should an Engineer be Trained?" by Sir Theodore Morison. 6 p.m.

Popular Talk in Aid of King Edward's Hospital Fund for London.—Fyvie Hall, Polytechnic, Regent-street, London, W. 1. "Liquid Air," by Mr. W. E. Garner. 5 p.m.

Railway Club.—25, Tothill-street, Westminster, London, S.W. 1. Paper, "Light Signalling," by Mr. W. J. Thorrowgood. 7.30 p.m.

SATURDAY, NOVEMBER 13TH.

Institution of Civil Engineers: Birmingham and District Association.—Visit to South Staffordshire Waterworks at Lichfield and Dudley. 11 a.m.

MONDAY, NOVEMBER 15TH.

Institution of Automobile Engineers: Scottish Centre.—Royal Technical College, Glasgow. Paper, "Recent Researches on Friction and Lubrication," by Mr. J. E. Southcombe. 7.30 p.m.

TUESDAY, NOVEMBER 16TH.

Institute of British Foundrymen: Lancashire Branch, Burnley Section.—Municipal College, Ormerod-road, Burnley. Lecture, "A Talk about the Cupola," by Mr. F. Perkins. 7.15 p.m.

Institution of Civil Engineers.—Great George-street, London, S.W. 1. Paper, "H.M. Dockyard, Rosyth," by Messrs. T. B. Hunter and A. L. Bell. 6 p.m.

Institution of Engineers and Shipbuilders in Scotland.—39, Elmbank-crescent, Glasgow. Paper, "Diesel Engines," by Mr. D. M. Shannon. 7.30 p.m.

WEDNESDAY, NOVEMBER 17TH.

Institution of Automobile Engineers.—Connaught Rooms, Great Queen-street, London, W.C. 2. Annual dinner. 7.15 for 7.30 p.m.

Institution of Civil Engineers.—Great George-street, London, S.W. 1. Students' meeting. Address by Mr. J. E. W. Monkhouse. 6.30 p.m.

Institution of Electrical Engineers: South Midland Centre.—The University, Edmund-street, Birmingham. Wireless Section meeting. Address by Professor C. L. Fortescue. 7 p.m.

THURSDAY, NOVEMBER 18TH

Institution of Automobile Engineers.—Watergate House, Adelphi, London, W.C. 2. London Graduates' meeting. Paper, "Worm Gears," by Mr. S. Miall. 7.30 p.m.

FRIDAY, NOVEMBER 19TH.

Junior Institution of Engineers.—39, Victoria-street, London, S.W. 1. Lecturette, "Short Wave Wireless Communication," by Mr. B. J. Axten. 7.30 p.m.

SATURDAY, NOVEMBER 20TH.

Institute of British Foundrymen: Lancashire Branch, Junior Section.—College of Technology, Manchester. Lecture, "The Foundry Cupola," by Mr. A. H. Goodger. 7 p.m.

FRIDAY, NOVEMBER 26TH.

Diesel Engine Users' Association.—Caxton Hall, Westminster, London, S.W. 1. Paper, "Modern Air Compressor Practice in Oil Engine Installations," by Mr. R. L. Quertier. 3.30 p.m.

Institution of Electrical Engineers: South Midland Centre.—Grand Hotel, Birmingham. Annual dinner. 6.30 for 7 p.m.

Tunnellers' Old Comrades Association.—Gatti's Restaurant, Strand, London, W.C. 2. Annual dinner. 7 for 7.30 p.m.